STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION COMMISSION

IN THE MATTER OF APPLICATION OF C.K. DISPOSAL, LLC, FOR PERMIT TO CONSTRUCT AND OPERATE A COMMERCIAL SURFACE WASTE MANAGEMENT FACILITY, PERMIT NO. NM1-61

CASE NO. 15617

LOUISIANA ENERGY SERVICES, LLC's EXHIBIT LIST

Louisiana Energy Services, LLC, may or will offer into evidence the following exhibits at the January 9 – 11, 2017 hearing in this matter:

A. C.K. Disposal Application excerpt – Attachment K.

B. C.K. Disposal Application excerpt – NMAC 19.15.36.8 – 19.15.36.20.

C. C.K. Disposal Application supplement – 09/9/16 Holder e-mail to Richardson. with attached H2S modeling study.

D. Aerial Photograph.

E. Aerial Photograph.

F. 2/18/11 M. Ritchie memorandum to Linda Gardner.

G. 6/2/11 M. Ritchie memorandum to Linda Gardner.

H. 10/19/15 M. Ritchie memorandum to Mark Peralta.

I. 2/2/16 Purafil Environmental Corrosivity Report.

J. Sundance Facility Video Clip (CD).

K. Section 5 Deeds:

K-1. 12/29/09 deed from Leo Sims, as PR of the Kennann Estate, to S&D Ranch.

K-2. 12/28/09 deed from Aline Sims, individually and as PR of the Sims Estate, to S&D Ranch.

K-3. 1/3/11 deed from S&D Ranch to Leo Sims, LLC.

K-4. 1/3/11 deed from Leo Sims, LLC, to EH & MC Clifford Living Trust.

K-5. 6/3/14 deed from Leo Sims, LLC, and EH & MC Clifford Living Trust deed to Davis et ux.

K-6. 4/27/15 Davis et ux. deed to Karger.

K-7. 5/27/15 Karger et ux. deed to Cope.

K-8. 6/19/15 Cope et ux. deed to CK Disposal.

K-9. 7/6/15 Karger et ux. deed to CK Disposal.

L. Section 32 Land Use Restriction or Condition Agreements:

L-1. 8/22/03 Land Use Restriction or Condition Agreement.

L-2. 8/3/10 First Amendment to Land Use Restriction or Condition Agreement.

M. Section 32 Business Leases:

M-1. 4/5/05 Business Lease BL-1689.

M-2. 11/15/05 Assignment of Business Lease BL-1689.

M-3. 9/26/07 Amendment to Business Lease BL-1689.

M-4. 4/5/10 Business Lease BL-1689-1.

M-5 8/5/13 Business Lease BL-2051.

N. Section 32 (South of Highway 176) Easement Instruments:

  N-1. 4/23/09 Easement No. R-30337.

  N-2. 4/29/15 Assignment of Easement No. R-30337.

  N-3. 4/30/15 Assignment of Easement No. R-30337.

  N-4. 5/27/15 Assignment of Easement No. R-30337.

O. August 2003 Section 32 Easement (LES) .

P. December 13, 2016 Bisbey-Kuehn letter to Karger.

Q. Clayton Orwig Resume.

R. Clayton Orwig Report.

S. Jay Peters Resume.

T. Jay Peters Report.

U. Nadia Glucksberg Resume.

V. Nadia Glucksberg Reports.

  V-1. Stormwater Issues.

  V-2. Migratory Bird Protection.

W. Ron Bohannan Resume.

X. Ron Bohannan Report.

Y. Matthew S. McGovern, Ph.D. Resume.

Z. Matthew S. McGovern, Ph.D. Report.

AA. Wind Rose.

BB. 2016 Khan Report.

CC. 2010 USFWS Report.

DD. 2016 Engle Report.

EE. 2004 Data Bulletin.

FF. 2007 Tems Report.

GG. 20.2.3 NMAC (Ambient Air Quality Standards).

HH. 20.2.70 NMAC (Operating Permits).

II. 20.2.72 NMAC (Construction Permits).

JJ. 20.2.73 NMAC (Notice of Intent and Emissions Inventory Requirements).

KK. 19.2.10.8, .9 and .17 NMAC (State Trust Land Easements and Rights of Way).

LL. 20.6.2.3101 and .3103 (NMAC Ground Water Standards).

MM. 18.3.6 NMAC (State Highway Access Management Requirements).

NN. 6/2/16 Sexton letter to Griswold and Catanach.

OO. 2012 Valdez Salas Report.

RODEY, DICKASON, SLOAN, AKIN & ROBB, P.A.

By:__________________________
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CERTIFICATE OF SERVICE:

We hereby certify that a copy of the
foregoing pleading was e-mailed on
February 2, 2017 to the following:

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January 27, 2017

Mr. Hank Bohnhoff
P.O. Box 1888
Albuquerque, NM 87103

RE: CK DISPOSAL FACILITY - EUNICE

Dear Mr. Bohnhoff:

Intent of Report

The intent of this report is to review and comment on the C.K. Disposal E& P Landfill and Processing Facility application. Tierra West LLC was engaged to review the application and the development and provide testimony related to the CK Disposal E & P Landfill and Processing Facility located along the south side of NM S.R. 176 (formerly 234) approximately 4.5 miles east of Eunice, NM. The new project encompasses a land area of approximately 317 acres (including 141.5 acres or Landfill, 51.75 acres Liquid Processing, and 5.1 acres Saltwater Disposal). Access to the new facility per the permit is located on the east property line of the CK Facility. This is approximately 520 feet east of the existing driveway to the Enrichment Uranium Facility directly across the street on the north side of NM S.R. 176.

Our scope of work was limited to the traffic, drainage and zoning impacts that the Landfill processing facility would have on the adjoining properties in the area. This report limits the review to those areas.

Zoning

Review of Lea County's subdivision regulations, the County does not have any specific zoning ordinances. Lea County does have a Comprehensive Plan which has been adopted but zoning is not required for the development. As such the only permits that a facility would be required would be those required by the State and Federal agencies. The proposed development will require being in compliance and securing a Land Fill Permit, A Driveway permit from the New Mexico Department of Transportation (NMDOT) and be in compliance with the Federal Clean Water Act.

Drainage & Clean Water Act

Review of the ordinances and records of Lea County, the County does not have any separate drainage ordinances that this facility needs to be in compliance with. The only Federal regulation they would need to be in compliance with is the Clean Water Act.. That act covers the disturbance of properties greater than one acre and requires treatment both during construction as well as post construction of the site. In reviewing the documents and specifically under Attachment J Drainage Study the Clean Water Act was not referenced. In addition, we could not find any details or design standards for Best Management Practices (BMP's) which would provide the basic structure regulating the discharge of pollutants into the waters of the United States.

The current design of the CK facility and resulting hydraulic calculations are referenced in the application under Attachment J. The project is using detention ponds to control the runoff and

EXHIBIT X

to protect the downstream property owners from any potential damage or impacts. Per the CKD permit application, Attachment J, the existing and proposed hydrologic and hydraulic conditions of the site are based on hydrologic computations performed using United States Army Corps HEC-HMS software and SCS unit hydrograph hydrology, which is the standard methodology developed by the United States Department of Agriculture – Natural Resources Conservation Service for calculating watershed runoff. Hydraulic structures design, erosion stability and the management of storm water run-on and run-off from the C. K. Facility site was based on a 25-year, 24-hour storm event. The calculations in Attachment J used a rainfall total of 4.88-inches for the 25-year, 24-hour storm event based on the NOAA Isopluvial Map included in Appendix D of Attachment J.

Detention ponds are placed adjacent to the property boundary at the southwest and southeast corners (reference Figure J.6), for the purpose of containing and managing stormwater. In the model, the drainage areas were assigned to drain to each of the ponds, as shown on Figure J.5 of the application, and the runoff volumes were based on Table J.2 of the application. The details of the pond geometry and depth were reviewed based on the information presented in Figure J.8 of the application.

The data on the pond construction and storm events indicate that the total calculated runoff volume of 33.7 acre-feet is more than the cumulative volume for the two detention ponds of 28.7 acre-feet. The excess drainage would then lead to overflow from the ponds during the modeled 25-year, 24-hour storm event and would impact the adjoining properties due to the placement of the ponds. The pond overflow structures are located within 10 feet of the property line. The comparison of the pond storage and runoff rates is shown in the attached calculations.

<table>
<tr><th colspan="7">Assessment of C.K. Disposal Pond Volume Calculations</th></tr>
<tr><th colspan="4">Detention Pond 2
Storage Volume
(Based on Graph on Drawing C-506)</th><th></th><th colspan="2">Detention Pond 2 Runoff Volume
(Based on Table J.2)</th></tr>
<tr><th>Depth (ft)</th><th>Area (ac)</th><th>Volume (ac-ft)</th><th>Cumulative Vol. (ac-ft)</th><th></th><th>Drainage Area</th><th>Volume (ac-ft)</th></tr>
<tr><td>0</td><td>1</td><td></td><td>0</td><td></td><td>3</td><td>2.6</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>2.4</td><td>1.7</td><td>2.7</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>4</td><td>3.2</td><td>5.9</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>5.3</td><td>4.65</td><td>10.55</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>6.4</td><td>5.85</td><td>16.4</td><td></td><td></td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><th colspan="4">Detention Pond 1
Storage Volume
(Based on Graph on Drawing C-506)</th><th></th><th colspan="2">Detention Pond 1 Runoff Volume
(Based on Table J.2)</th></tr>
</table>

Depth (ft)	Area (ac)	Volume (ac-ft)	Cumulative Vol. (ac-ft)
0	0.25		0
2	0.25	0.5	0.5
4	0.45	0.7	1.2
6	0.65	1.1	2.3
8	1.4	2.05	4.35
10	2.25	3.65	8
11.8	2.5	4.275	**12.3**

Drainage Area	Volume (ac-ft)
1	4.3
2	3.2
4	6.3
5	4.6
6	5
7	5.1
8	5.2
Total	**33.7**

The design has only a gabion structure for an overflow which if any event larger than a 25 year, 24-hour event will spill to the adjoining property. Experience on the overflow shows during a greater event that the spillway would have a high chance of failing creating a surge of water from the detention facility to impact downs stream properties.

As mentioned the design was based upon the 25-year, 24-hour storm event versus the industry standard 100-year even. This facility is using a total detention facility, which means it will capture all of the water during that event. In the arid southwest industry standard (when using detention) is to use the 100 year, 10-day storm event. The southwest is subject to high intensity low duration storms and during the summer months if the detention facility does not evaporate or drain within 24 hours there is a high probability that the storm will overtop the facility.

The 100-year, either 6-hour or 10-day event has been recognized within Region 6 EPA which reviews all discharges over 1 acre of disturbance. The short duration, high frequency storms can result in intense rainfall amounts that would exceed any improvements designed for just a 25-year event.

Post controls need to be shown on how the project will not provide a discharge of pollutants off the site and showing how those will be handled and maintained in the event that a 100 year event would occur.

Additional details needs to be provided to determine if the BMP or Best Management Practices are adequate. Those need to include the amount, frequency, intensity and duration of the precipitation including but not limited to the following:

1. The nature of stormwater runoff and run-on at the site, including factors such as expected flow from impervious surfaces, slopes, and site drainage features. If any stormwater flow will be channelized at your site, you must design stormwater controls to control both peak flowrates and total stormwater volume to minimize erosion at outlets and to minimize downstream channel and streambank erosion; and

2. The range of soil particle sizes expected to be present on the site.

3 You must direct discharges from your stormwater controls to vegetated areas of your site to increase sediment removal and maximize stormwater infiltration, including any natural buffers established under Part 2.1.2.1, unless infeasible. Use velocity dissipation devices if necessary to prevent erosion when directing stormwater to vegetated areas.

4. Soil loss calculations need to be provided based upon soil loss prediction software (RUSLE, SEDCAD, SEDIMOT, MULTISED etc.)

Finally, all post controls need to be monitored so that the detention ponds, if filled with sediment, are maintained and operate as designed.

Traffic

Review of the traffic impacts needs to assess the proposed development along with the existing Enrichment Uranium Facility directly across the street on the north side along with the background traffic on NM S.R. 176. The C.K. Disposal E&P Landfill and process facility encompasses a land area of approximately 317 acres (including 141.5 acres or Landfill, 51.75 acres Liquid Processing, and 5.1 acres Saltwater Disposal. Access to the new facility will be via a proposed driveway near the east side of the project which will be aligned with the existing driveway to the existing Enrichment Uranium Facility directly across the street on the north side of NM S.R. 176. This analysis assumes that the new CK Disposal Facility will generate traffic based on 198.35 acres of General Heavy Industrial Use as defined in the Institute of Transportation Engineers (ITE) Trip Generation Manual, current edition (also see Sheet A-4):

CK Facility (NM S.R, 176 E. of Eunice, NM)
Trip Generation Data (ITE Trip Generation Manual - 9th Edition)

USE (ITE CODE)	Units	24 HOUR TWO-WAY VOLUME	A.M. PEAK HOUR		P.M. PEAK HOUR	
		GROSS	ENTER	EXIT	ENTER	EXIT
General Heavy Industrial (120)	198.35 Acres	1,339	314	79	86	343

The Uranium Enrichment Facility on the north side of NM S.R. 176 lies on approximately 600 acres of land. Of the 600 acres, approximately 2/3 of the land is vacant (i.e., not buildings or parking lot). The net acreage of the facility is approximately 200 acres. The Facility fronts on NM S.R. 176 for about one mile. There are two access points onto NM S.R. 176 – one near the east end of the facility and one approximately 3,500 feet to the west. The existing west driveway is to be closed soon. The Google Earth aerial photo of the Uranium Enrichment Facility parcel (image date – 11/22/2016) indicates the ability to park approximately 300 vehicles on-site. The trip generation rate for this facility has been derived from recent traffic count data collected by Pettrigew & Associates in Hobbs, New Mexico. A summary of the trip generation results are in the following table:

Uranium Enrichment Facility

Trip Generation Data (ITE Trip Generation Manual - 9th Edition)

USE (ITE CODE)		24 HOUR TWO-WAY VOLUME	A.M. PEAK HOUR		P.M. PEAK HOUR	
		GROSS	ENTER	EXIT	ENTER	EXIT
	Units					
Uranium Enrichment Facility		986	128	10	76	76

(Taken from Pettigrew Traffic Count Data)

It should be noted that the Uranium Enrichment Facility has two access points along NM S.R. 176. Plans are to close the west driveway soon. Therefore, the entirety of trips generated by the Uranium Enrichment Facility will be assigned to the east driveway.

The New Mexico Department of Transportation reports that the Average Annual Daily Traffic on NM S.R. 176 approximately 2 miles east of Eunice was 4,257 in 2015. As a rule of thumb, the peak hour on a roadway is approximately 15% of the daily traffic. Therefore, the peak hour traffic on NM S.R. 176 can be estimated at 640 vehicles per hour (both directions). It will be assumed that the traffic is split 50% - 50% directionally. Also, the New Mexico Department of Transportation reports that the heavy commercial traffic on this section of NM S.R. 176 is 54% (see attached TIMS sheet).

The existing driveway (Uranium Enrichment Facility east driveway) was analyzed for the current condition (AM and PM Peak Hours) based on assumptions described above. Subsequently, the existing driveway was analyzed again as a four-legged driveway assuming that the CK Disposal driveway would be constructed to align with the existing Uranium Enhancement facility driveway. Thirdly, the CK Disposal driveway was analyzed assuming that it would be offset to the east of the existing Uranium Enrichment Facility driveway (approximately 520 feet offset). A summary of the results of the three analyses are summarized in the following table:

Intersection: 1 - NM S.R 176 / E. Driveway

2016 AM Peak Hour BUILD

		(EXIST. GEOM.)				(OFFSET DRIVE)	
		NO BUILD		BUILD		BUILD	
		Lanes	LOS-Delay	Lanes	LOS-Delay	Lanes	LOS-Delay
EB	L	1	A - 8.8	1	A - 8.8	1	A - 9.0
	T	1	A - 0.0	1	A - 0.0	1	A - 0.0
	R	1	A - 0.0	1	A - 0.0	1	A - 0.0
WB	L	1	A - 0.0	1	A - 9.7	1	A - 8.6
	T	1	A - 0.0	1	A - 0.0	1	A - 0.0
	R	1	A - 0.0	1	A - 0.0	1	A - 0.0
NB	L	>	A - 0.0	>	F - 53.0	>	A - 0.0
	T	1	A - 0.0	1	F - 53.0	1	A - 0.0
	R	>	A - 0.0	>	F - 53.0	>	A - 0.0
SB	L	>	C - 22.0	>	F - 87.5	>	D - 27.5
	T	1	A - 0.0	1	F - 87.5	1	A - 0.0
	R	>	C - 22.0	>	F - 87.5	>	D - 27.5
Intersection:			*u - 3.7*		*u - 14.6*		*u - 3.7*

2016 PM Peak Hour BUILD

	(EXIST. GEOM.)				(OFFSET DRIVE)	
	NO BUILD		BUILD		BUILD	
	Lanes	LOS-Delay	Lanes	LOS-Delay	Lanes	LOS-Delay
L	1	A - 9.0	1	A - 9.0	1	A - 9.9
T	1	A - 0.0	1	A - 0.0	1	A - 0.0
R	1	A - 0.0	1	A - 0.0	1	A - 0.0
L	1	A - 0.0	1	A - 9.0	1	A - 8.7
T	1	A - 0.0	1	A - 0.0	1	A - 0.0
R	1	A - 0.0	1	A - 0.0	1	A - 0.0
L	>	A - 0.0	>	F - 339	>	A - 0.0
T	1	A - 0.0	1	F - 339	1	A - 0.0
R	>	A - 0.0	>	F - 339	>	A - 0.0
L	>	C - 18.4	>	E - 49.5	>	D - 27.2
T	1	A - 0.0	1	E - 49.5	1	A - 0.0
R	>	C - 18.4	>	E - 49.5	>	D - 27.2
		u - 2.2		*u - 99.4*		*u - 2.4*

Note: ">" designates a shared right or left turn lane.

Under the existing condition, the preceding table demonstrates a probability that the existing driveway to the Uranium Enrichment facility operates at an acceptable level-of-service during the AM Peak Hour and a marginally acceptable level-of-service during the PM Peak Hour without the addition of the CK Disposal Facility. Addition of the fourth leg of the intersection (for the CK Disposal Facility) results in unacceptable long delays at the driveway, both during the AM Peak Hour and the PM Peak Hour. The projected delay on the northbound leg (CK Disposal driveway) during the PM Peak Hour is 339 seconds average control delay. Additionally, the addition of the fourth leg of the driveway (intersection) increases the calculated delay for the existing Uranium Enrichment Facility driveway from 22.0 seconds to 87.5 seconds during the AM Peak Hour and from 18.4 seconds to 49.5 seconds during the PM Peak Hour period. The adverse impact of adding a fourth leg to the existing Uranium Enrichment Facility driveway is significant.

The effect on the Uranium Enrichment Facility driveway resulting from offsetting the new CK Disposal facility driveway approximately 520 feet to the east is evaluated in the above table in the third columns. The resulting calculated average control delay for the northbound approach of the driveway is 27.5 seconds for the AM Peak Hour and 27.2 seconds for the PM Peak Hour period. The impact of offsetting the CK Disposal driveway approximately 520 feet to the east is more severe when considering the required left turn deceleration lanes at the new driveway which would conflict with the existing County Landfill driveway approximately 340 feet to the east and would require elimination of the southbound to eastbound acceleration lane from the Uranium Enrichment Facility driveway. The offset CK Disposal Facility Driveway is projected to operate at LOS "E" (AM Peak) or LOS "F" (PM Peak) based on the assumptions in this analysis.

The 2010 Highway Capacity Manual defines Level of Service (LOS) for un-signalized intersections in terms of average controlled delay per vehicle also. The following table summarizes the thresholds for various levels of service at un-signalized intersections:

LOS A	0 to10.0"
LOS B	10 to 15"
LOS C	15 to 25"
LOS D	25 to 35"
LOS E	35 to 50"
LOS F	> 50"

Level-of-Service "D" is generally considered acceptable in urban areas and is the desirable base condition for analysis in a traffic study. Some rural areas consider Level-of-Service "C" to be the minimum acceptable standard. In addition to consideration of the overall level-of-service of the un-signalized intersection, the levels-of-service of each individual movement should be considered also.

According to the New Mexico Department of Transportation's TIM Road document, NM S.R. 176 is classified as a Major Collector roadway. Due to the location of this particular project, this segment of NM S.R. 176 would be classified as a Rural Major Collector Roadway. Minimum driveway / intersection spacing standards on New Mexico Department of Transportation's roadways are established by Table 18.C-1 (Access Spacing Standards for Intersections and Driveways) from the *State Access Management Manual*. Based on the roadway classification and the posted speed on NM S.R. 176, the minimum driveway spacing *for full access driveways (traversable median) is 550 feet (centerline to centerline)*. Therefore, the CK Disposal Facility driveway will be required to be located at least 550 feet east of the existing Uranium Enrichment Facility driveway order to meet New Mexico Department of Transportation minimum driveway spacing requirements.

The Synchro[1] Un-signalized Intersection Analysis reports on Appendix Pages A-10 thru A-17 of this report also calculate the 95th Percentile Queue Lengths for the controlled movements at the driveway. A summary of the queuing analysis is in the following table:

	AM Peak Hour		PM Peak Hour	
Case	**NO BUILD**	**BUILD**	**NO BUILD**	**BUILD**
EB Left Turn	1	1	1	1
WB Left Turn	N/A	1	N/A	1
NB	N/A	3	N/A	26
SB	2	7	1	3

Queues in preceding table are expressed in number of vehicles rounded up. Calculated decimal queue lengths are not realistic. In consideration of the large percentage of tanker trucks entering and exiting this site, the expected queue length per vehicles is up to 60 feet. The following table summarizes the calculated 95th Percentile Queue Lengths for the proposed CK driveway if it is offset to the east of the existing driveway:

	AM Peak Hour		PM Peak Hour	
Case	**NO BUILD**	**BUILD**	**NO BUILD**	**BUILD**
WB Left Turn	N/A	1	N/A	1
NB	N/A	3	N/A	14

Based on the results of this analysis as described above, the CK Disposal Facility driveway, if aligned with the existing Uranium Enrichment Facility driveway, will result in excessive and unacceptable vehicular delays and queue lengths for both the CK Disposal Facility driveway as well as the Uranium Enrichment Facility driveway. It is not recommended that the proposed CK Disposal Facility Driveway be aligned with the existing Uranium Enhancement Facility driveway. The proposed CK Disposal Facility driveway will be required to be located at least 550 feet east of the existing Uranium Enrichment Facility driveway in order to meet the minimum spacing requirement of Table 18.C-1 (Access Spacing Standards for Intersections and Driveways) of the New Mexico Department of Transportation's *State Access Management Manual*. This access location is further east than the property line and

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[1] Synchro by SimTraffic is Traffic Engineering Software that evaluates the performance of signalized and / or unsignalized intersections based on the 2010 Highway Capacity Manual developed by the Transportation Research Board of the National Academy of Sciences in the United States.

then creates a conflict with the County Landfill access to the east approximately 340 feet east of the CK east property line.

At any location for access the CK Disposal Facility driveway will be required to have an eastbound right turn deceleration lane and a westbound left turn deceleration lane on NM S.R. 176 at the new driveway. The eastbound and westbound deceleration lanes will be required as per the New Mexico Department of Transportation's State Access Management *Manual* (Tables 17.B-3, 17.B-5, and 18.K-1). *Under any scenario and considering that most* of the entering traffic to the new CK Disposal Facility is likely to be tanker trucks and other heavy commercial vehicles the total length of the deceleration and acceleration lanes will be 800 feet. This length is based upon (the posted speed limit on NM State Rd. 176 is 55 MPH along the frontage of the CK Disposal project. Table 18.K-1 (Deceleration and Acceleration Lengths) in the New Mexico Department of Transportation's State Access Management Manual stipulates that the minimum deceleration lane length for a left turn lane at 55 MPH is 550 feet long plus transition (another 200 feet). To the required 550 feet length, add another 50 feet to account for the westbound left turn queuing of one tanker truck. The total required length, then, for the westbound left turn lane would be 600 feet plus 200 feet transition for a total of 800 feet).

A required westbound left turn lane on NM 176 at the CK Disposal Facility offset driveway would extend through the existing driveway to the County Landfill approximately 340 feet to the east, and it would require elimination of the existing southbound to eastbound acceleration lane from the Uranium Enrichment Facility. Therefore, the offset driveway option for the CK Disposal project is not recommended. A mitigating measure to possibly resolve some of the deceleration lane issues is to consolidate the CD Disposal Driveway with the County Landfill Driveway and relocated both further east to achieve required acceleration lane requirements for the eastbound acceleration lane. It is important to meet not only the New Mexico Department of Transportation's minimum driveway spacing standards, but also provide sufficient separation of the driveways to fit the required left turn deceleration lanes and acceleration lanes for the CK Disposal project.

The traffic entrance problems that are associated with the proposed CK Disposal Facility driveway are as follows:

- If the CK Disposal Driveway were to be aligned with the existing Uranium Enrichment Facility driveway, the calculated delays and queuing at the four-legged intersection will be unacceptable.
- Offsetting the CK Disposal Driveway to the east will result in the New Mexico Department of Transportation's driveway spacing requirements to not be met. Either the CK Disposal driveway will be too close to the Uranium Enrichment Facility driveway or the County Landfill driveway to the east or both. Also, offsetting the CK Disposal driveway will result in conflicts with existing and proposed required deceleration and acceleration lanes for each of the three driveways – the Uranium Enrichment Facility driveway, the County Landfill driveway, and the proposed CK *Disposal driveway.*

Summary

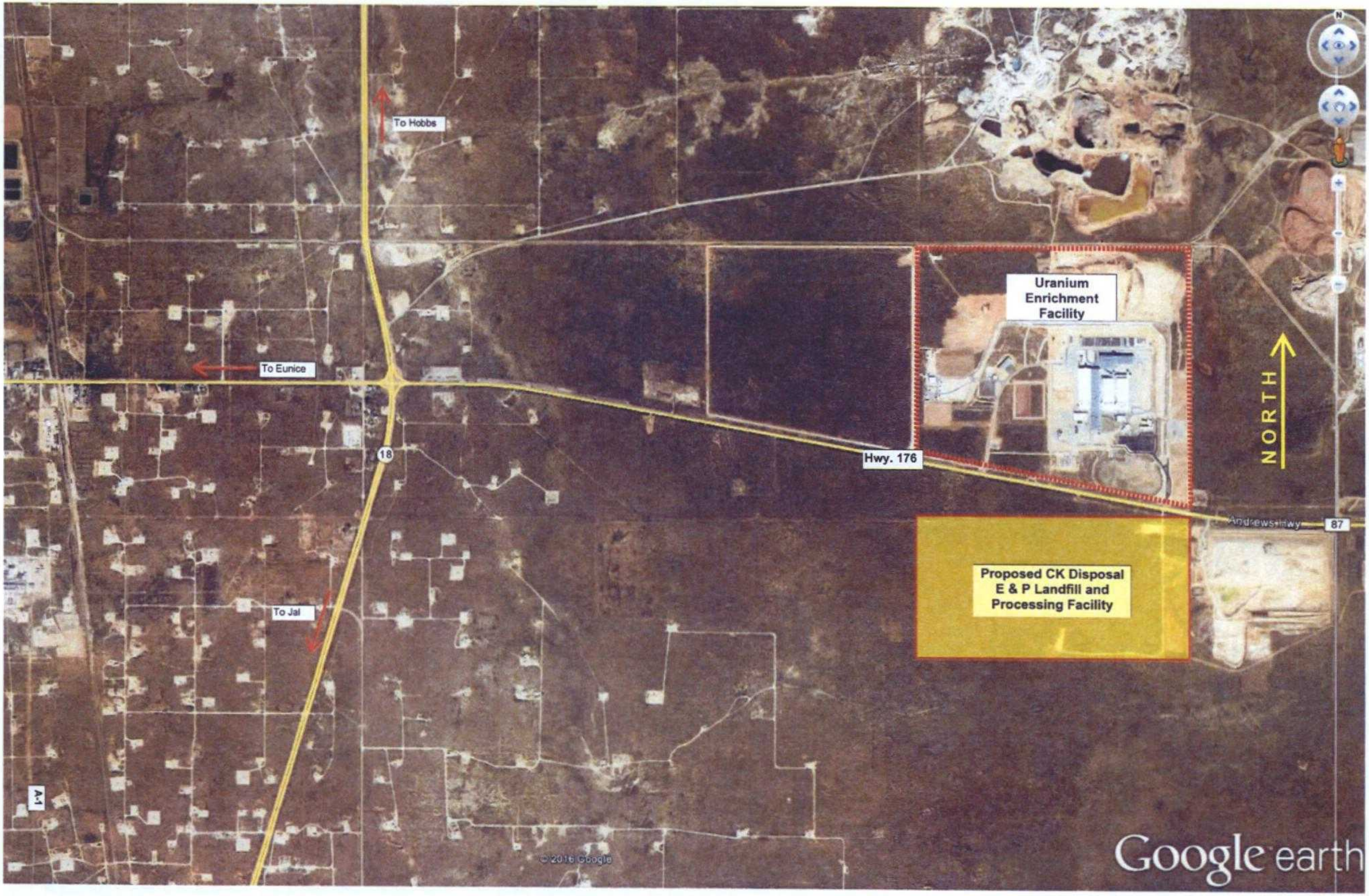
In summary the proposed facility will impact both the existing Enrichment Facility as well as N.M. SR 176 which needs to be mitigated. The traffic impact will impact the existing access with unacceptable vehicular delays and queue lengths for both the CK Disposal Facility and the Enrichment Facility. The Drainage needs to be analyzed and the 100-year/24 hour event needs to be used for the analysis and adequate post construction facilities constructed on site. Under the proposed application the 25-year detention ponds are under capacity. The application needs to be in compliance with the pre and post control measures that will meet the Federal Clean Water Act.

If you have any questions or need additional information regarding this report, please do not hesitate to contact me.

Sincerely,

Ronald R. Bohannan, PE

JN: 2016088
RRB/ kw


To Hobbs
To Eunice
Uranium Enrichment Facility
NORTH
18
Hwy. 176
Andrews Hwy
87
Proposed CK Disposal E & P Landfill and Processing Facility
To Jal
A-1
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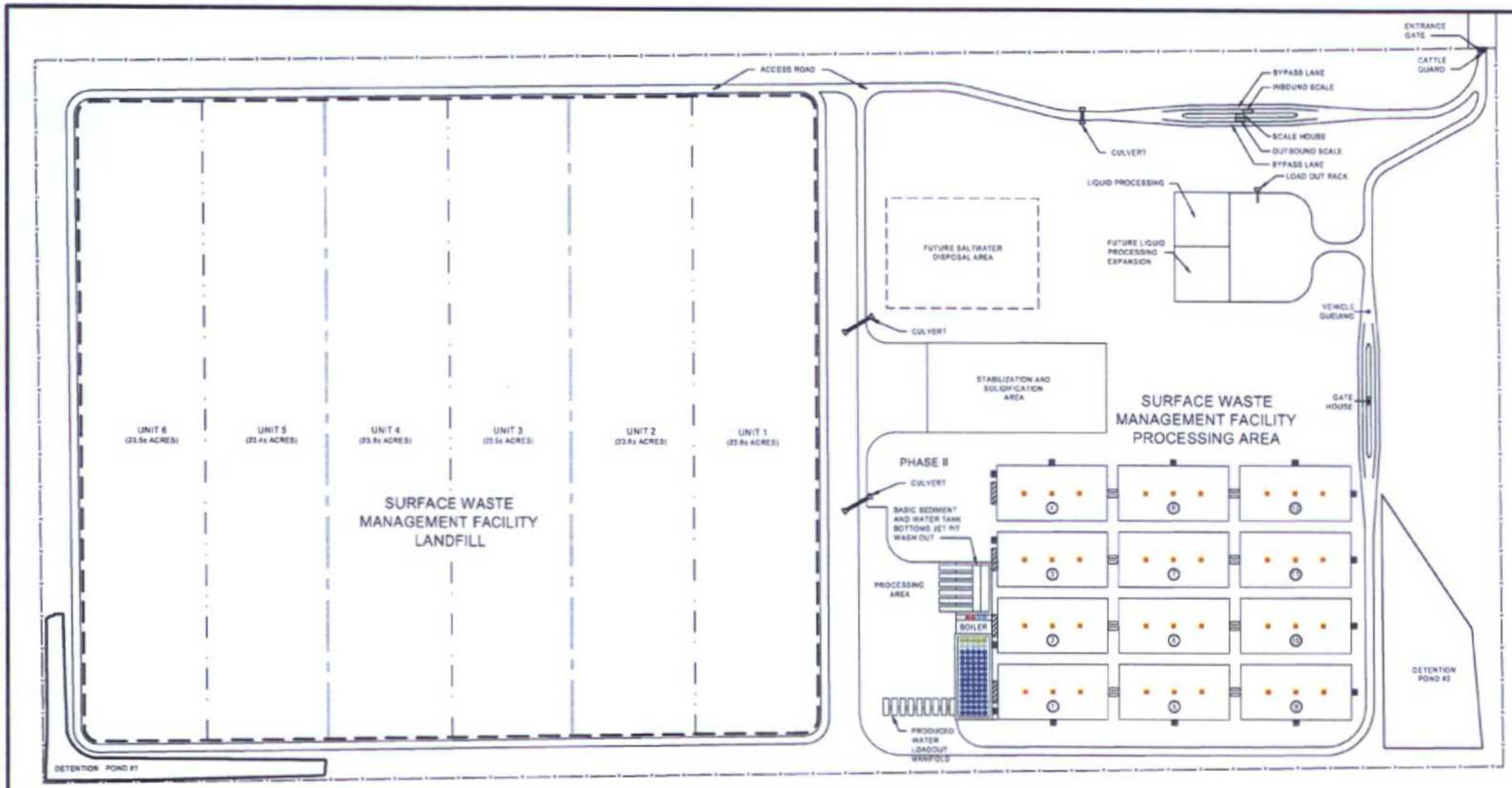
Google earth



LEGEND

—·—·—	FENCE/LANDFILL PROPERTY/PERMIT BOUNDARY
— — —	LANDFILL FOOTPRINT
— - —	LANDFILL PHASE LINE
—··—	UNIT LIMITS
▨	MECHANICAL OIL/WATER SEPARATOR
●	EVAPORATOR
■	MONITORING POINTS
⊜	LOW WATER CROSSING
●	PRODUCED WATER SETTING TANK
●	OIL RECOVER TANK
●	OIL SALES TANK
●	CHEMICAL TANK
●	JET OUT WATER TANK
⑤	EVAPORATION POND NUMBER

NICHOLAS N. YBARRA
20683

Nicholas N. Ybarra
11/6/2015

PSC
PARKHILL SMITH & COOPER

C. K. DISPOSAL E & P LANDFILL & PROCESSING FACILITY

NMED PERMIT NO. __

NEW LANDFILL SITE & PROCESSING FACILITY

LEA COUNTY, NEW MEXICO

KEY PLAN

NO	DATE	DESCRIPTION
1	09/23/15	ISSUE FOR REVIEW

ISSUING OFFICE: EL PASO   PROJECT NO: 0580.15

SITE DEVELOPMENT PLAN

FIG.A.2

Uranium Enrichment Facility

Trip Generation Data (ITE Trip Generation Manual - 9th Edition)

USE (ITE CODE)	**24 HOUR TWO-WAY VOLUME**	**A. M. PEAK HOUR**		**P. M. PEAK HOUR**	
	GROSS	***ENTER***	***EXIT***	***ENTER***	***EXIT***
Units					
General Heavy Industrial (120)	986	128	10	76	76

(Taken from Pettigrew Traffic Count Data)

<u>ITE Trip Generation Equations:</u>

Average Vehicle Trip Ends on a Weekday (24 HOUR TWO-WAY VOLUME)

T = *6.75* (X) + *0*

50% Enter, ***50%*** Exit

Average Vehicle Trip Ends on a Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7am and 9am (A.M. PEAK HOUR)

T = *1.98* (X) + *0*

80% Enter, ***20%*** Exit

Average Vehicle Trip Ends on a Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4pm and 6pm (P.M. PEAK HOUR)

T = *2.16* (X) + *0*

20% Enter, ***80%*** Exit

Comments:

Tract No.

Based on ITE Trip Generation Manual - 9th Edition

CK Facility (NM S.R. 176 E. of Eunice, NM)
Trip Generation Data (ITE Trip Generation Manual - 9th Edition)

USE (ITE CODE)	Units	24 HOUR TWO-WAY VOLUME	A. M. PEAK HOUR		P. M. PEAK HOUR	
		GROSS	ENTER	EXIT	ENTER	EXIT
General Heavy Industrial (120)	198.35 **Acres**	1,339	314	79	86	343

ITE Trip Generation Equations:

Average Vehicle Trip Ends on a Weekday (24 HOUR TWO-WAY VOLUME)

$T = 6.75(X) + 0$

50% Enter, *50%* Exit

Average Vehicle Trip Ends on a Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7am and 9am (A.M. PEAK HOUR

$T = 1.98(X) + 0$

80% Enter, *20%* Exit

Average Vehicle Trip Ends on a Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4pm and 6pm (P.M. PEAK HOUR

$T = 2.16(X) + 0$

20% Enter, *80%* Exit

Comments:

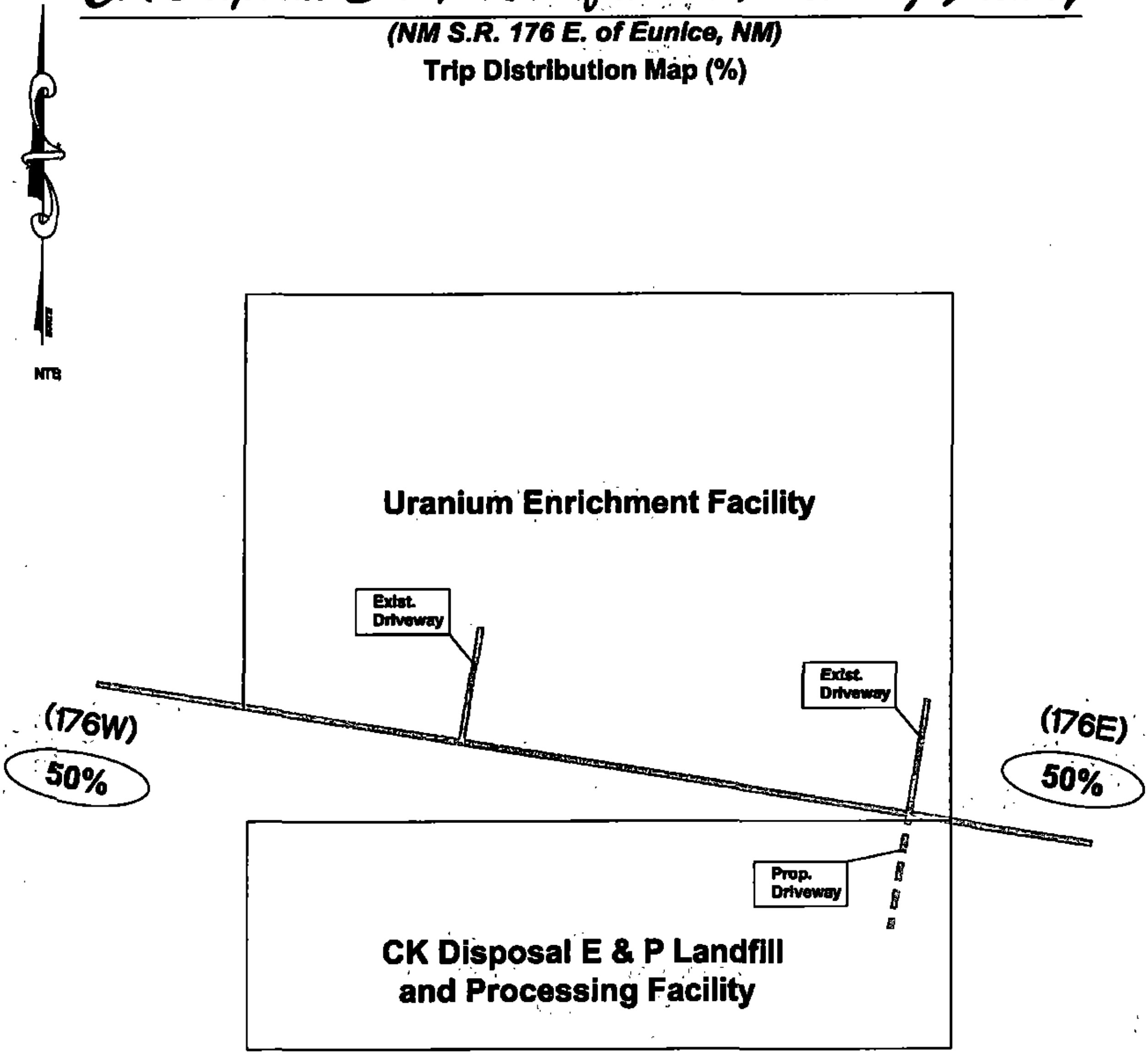
Tract No.

Based on ITE Trip Generation Manual - 9th Edition

CK Disposal E & P Landfill and Processing Facility

(NM S.R. 176 E. of Eunice, NM)

Trip Distribution Map (%)



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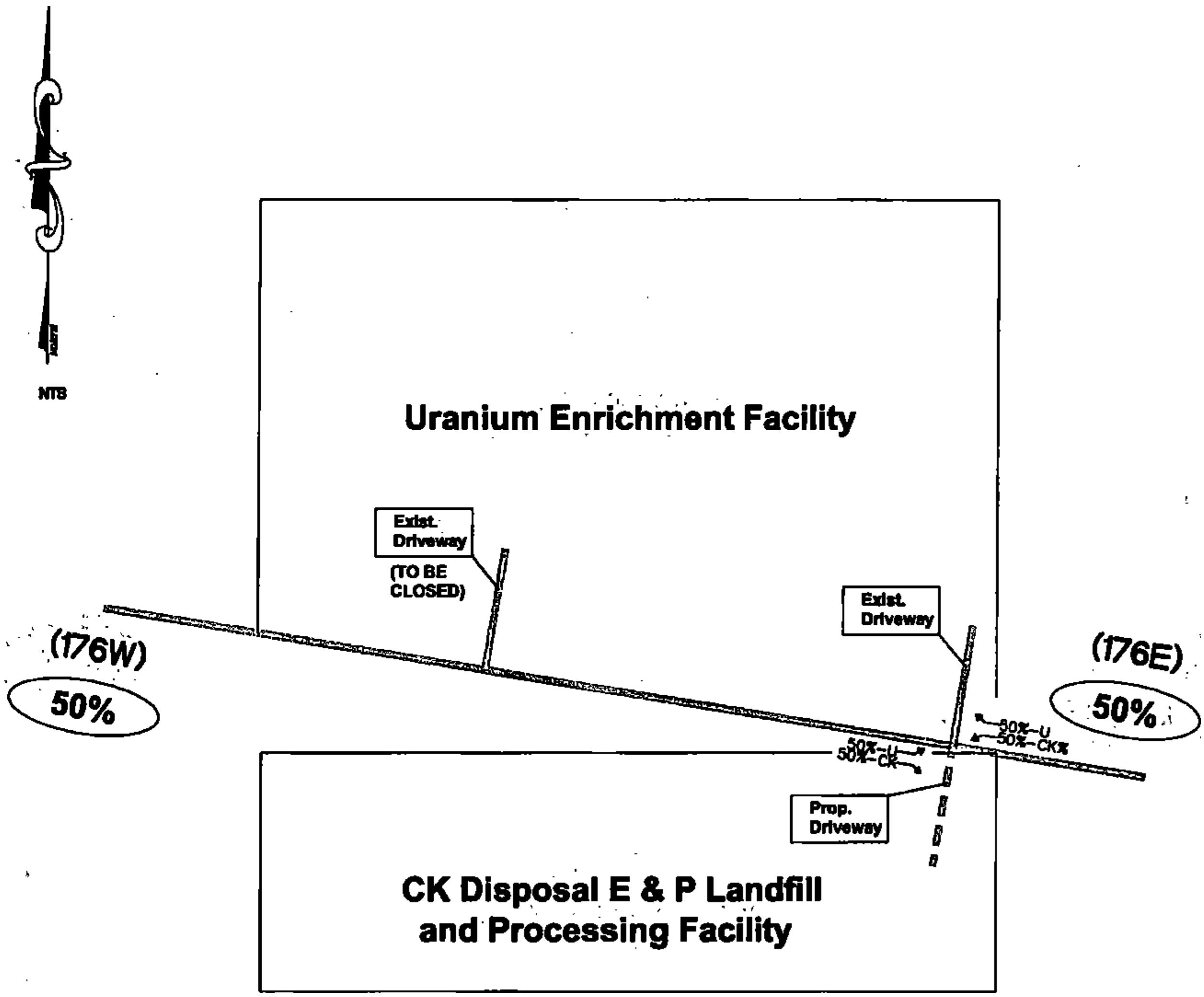
Albuquerque, NM 87199-2051
(505)883-8807 (Voice)
(505)212-0267 (Fax)

CK Disposal E & P Landfill and Processing Facility

(NM S.R. 176 E. of Eunice, NM)

Trip Assignments (% Entering)



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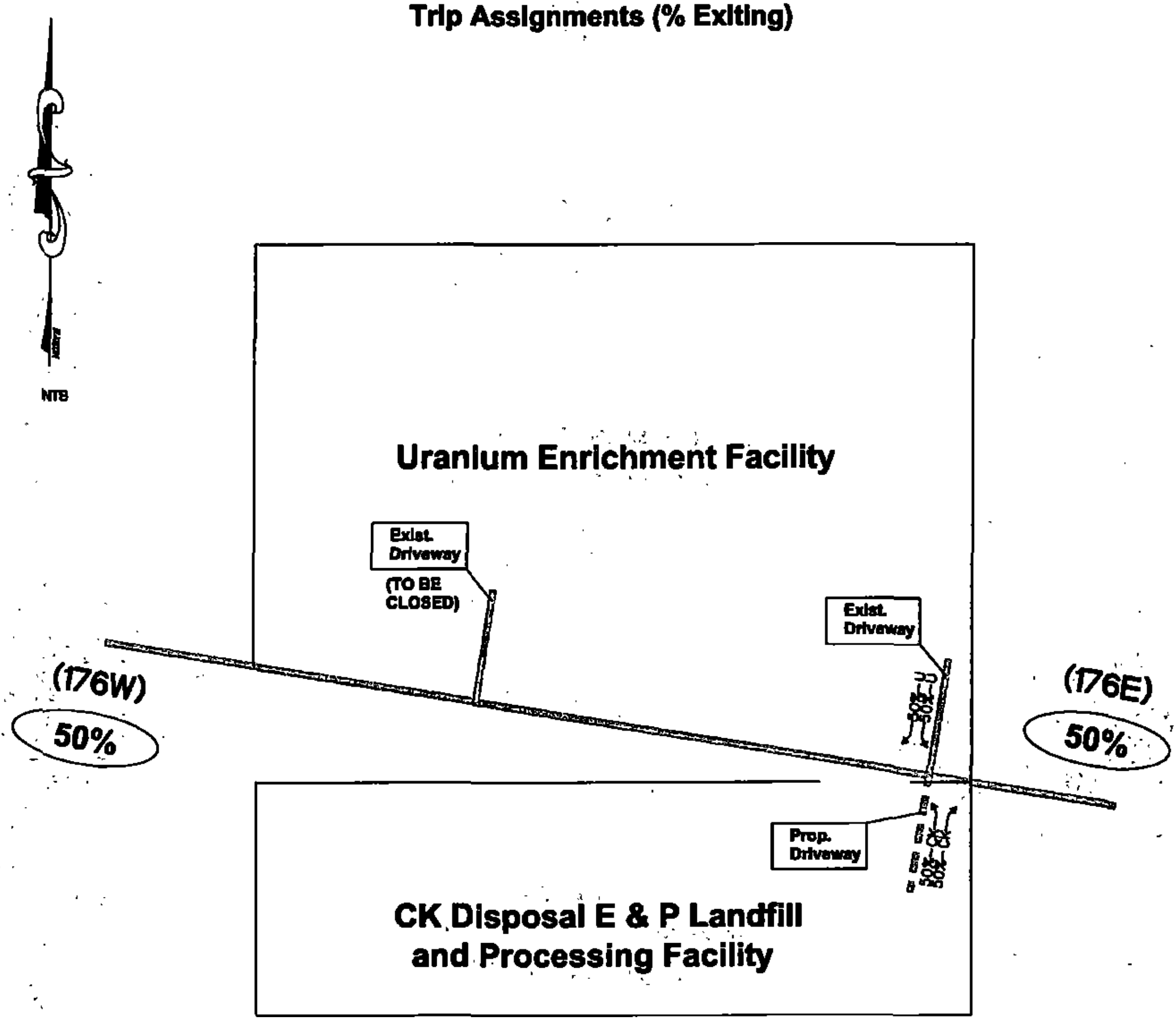
CK Disposal E & P Landfill and Processing Facility

(NM S.R. 176 E. of Eunice, NM)

Trip Assignments (% Exiting)



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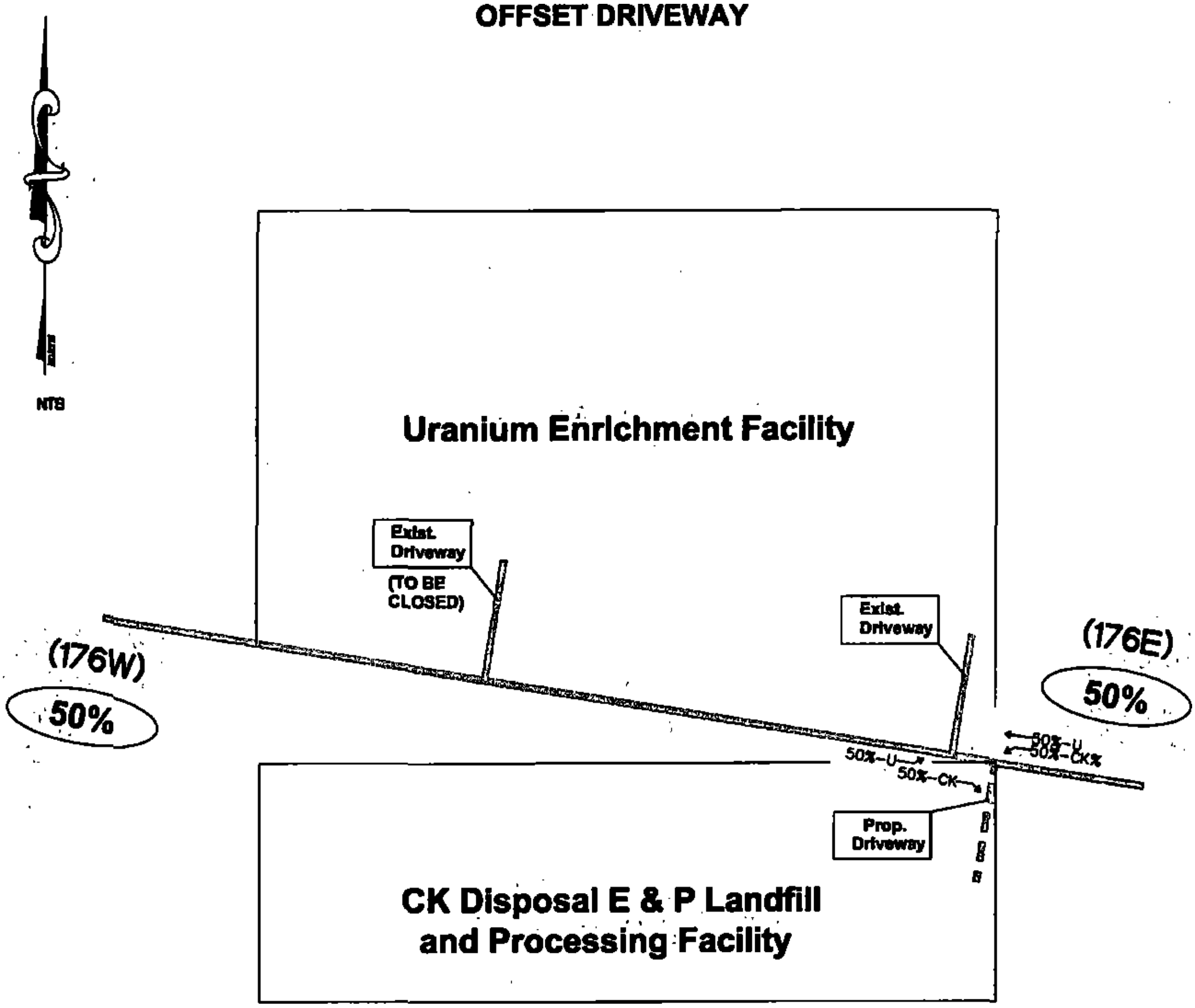
CK Disposal E & P Landfill and Processing Facility

(NM S.R. 176 E. of Eunice, NM)

Trip Assignments (% Entering)

OFFSET DRIVEWAY



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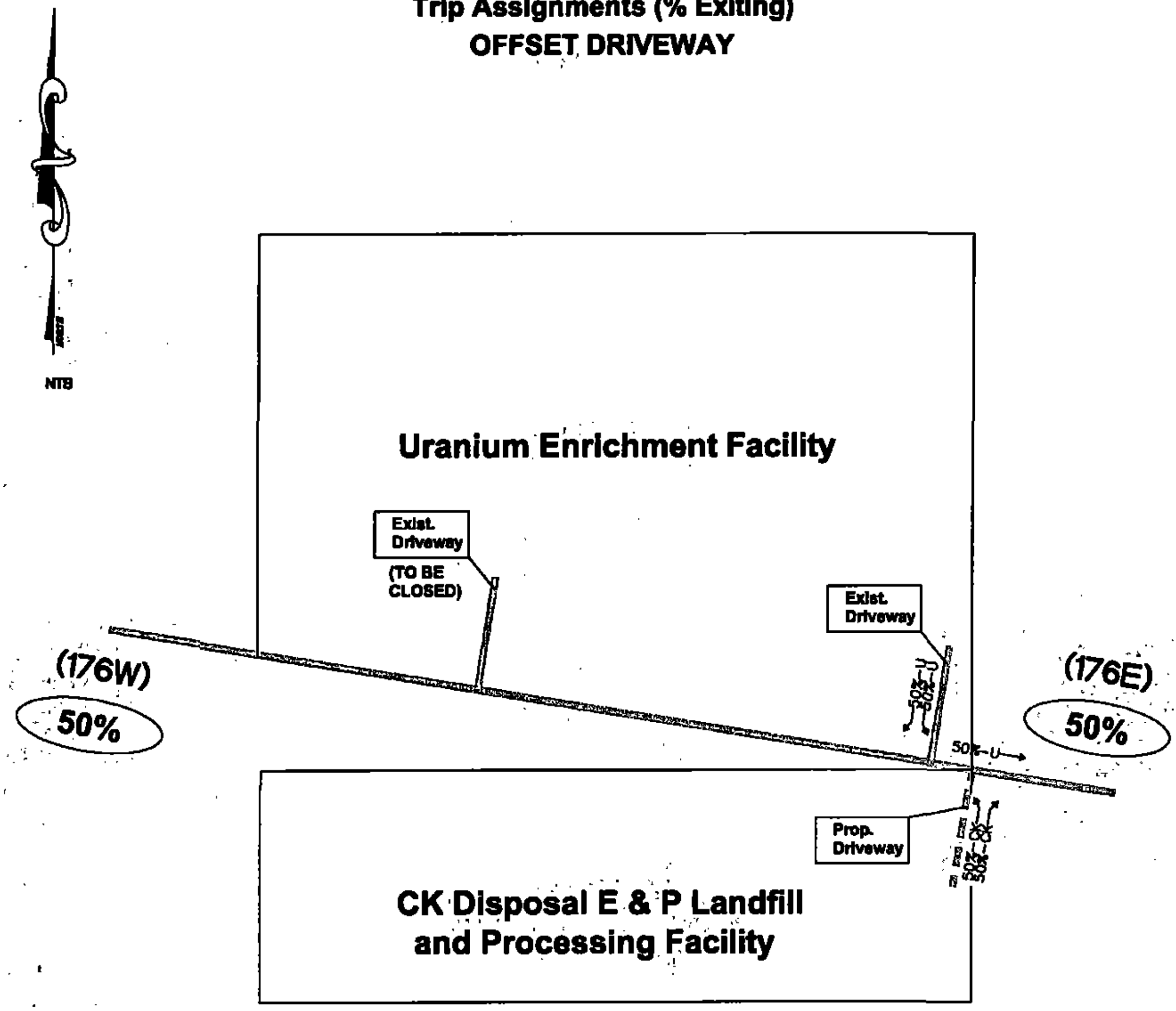
CK Disposal E & P Landfill and Processing Facility

(NM S.R. 176 E. of Eunice, NM)

Trip Assignments (% Exiting)

OFFSET DRIVEWAY



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CK Disposal E & P Landfill and Processing Facility (NM S.R. 176 E. of Eunice, NM)

Projected Turning Movements Worksheet

NM S.R. 176 / CK Driveway

INTERSECTION:

E-W Street: **NM S.R. 176** (1)
N-S Street: **CK Driveway** **(Uranium Enrichment Facility Driveway)**

Year of Existing Counts	2016
Implementation Year	**2016**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (CK Driveway)			Southbound (CK Driveway)		
Growth Rates	0.00%			0.00%			0.00%			0.00%		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	5	0	0	0	0	5	0	0	0	64	0	64
Subtotal (NO BUILD - A.M.)	***5***	***320***	***0***	***0***	***320***	***5***	***0***	***0***	***0***	***64***	***0***	***64***
Percent CK Trips Generated(Entering)	*0.00%*	*0.00%*	***50.00%***	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent CK Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	0	157	157	0	0	40	0	40	0	0	0
Total AM Peak Hour BUILD Volumes	**5**	**320**	**157**	**157**	**320**	**5**	**40**	**0**	**40**	**64**	**0**	**64**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (CK Driveway)			Southbound (CK Driveway)		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	38	0	0	0	0	38	0	0	0	38	0	38
Subtotal (NO BUILD - P.M.)	***38***	***320***	***0***	***0***	***320***	***38***	***0***	***0***	***0***	***38***	***0***	***38***
Percent CK Trips Generated(Entering)	*0.00%*	*0.00%*	***50.00%***	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent CK Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	0	43	43	0	0	172	0	172	0	0	0
Total PM Peak Hour BUILD Volumes	**38**	**320**	**43**	**43**	**320**	**38**	**172**	**0**	**172**	**38**	**0**	**38**

	Entering	Exiting		
Number of CK Trips Generated	**314**	**79**	A.M.	100% Development
	86	**343**	P.M.	

CK Disposal E & P Landfill and Processing Facility (NM S.R. 176 E. of Eunice, NM)

Projected Turning Movements Worksheet

NM S.R. 176 / CK Driveway

INTERSECTION: E-W Street: **NM S.R. 176** (2)
N-S Street: **CK Driveway** **(OFFSET) - - -**

Year of Existing Counts 2016
Implementation Year **2016**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (CK Driveway)			Southbound (CK Driveway)		
Growth Rates	0.00%			0.00%			0.00%			0.00%		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	0	64	0	0	5	0	0	0	0	0	0	0
Subtotal (NO BUILD - A.M.)	***0***	***384***	***0***	***0***	***325***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Percent CK Trips Generated(Entering)	*0.00%*	*0.00%*	***50.00%***	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent CK Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	0	157	157	0	0	40	0	40	0	0	0
Total AM Peak Hour BUILD Volumes	**0**	**384**	**157**	**157**	**325**	**0**	**40**	**0**	**40**	**0**	**0**	**0**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (CK Driveway)			Southbound (CK Driveway)		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	0	38	0	0	38	0	0	0	0	0	0	0
Subtotal (NO BUILD - P.M.)	***0***	***358***	***0***	***0***	***358***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Percent CK Trips Generated(Entering)	*0.00%*	*0.00%*	***50.00%***	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent CK Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	0	43	43	0	0	172	0	172	0	0	0
Total PM Peak Hour BUILD Volumes	**0**	**358**	**43**	**43**	**358**	**0**	**172**	**0**	**172**	**0**	**0**	**0**

	Entering	Exiting		
Number of CK Trips Generated	**314**	**79**	A.M.	100% Development
	86	**343**	P.M.	

CK Disposal E & P Landfill and Processing Facility (NM S.R. 176 E. of Eunice, NM)

Projected Turning Movements Worksheet

NM S.R. 176 / Ur Enrich. Dwy

INTERSECTION: E-W Street: **NM S.R. 176** (3)
N-S Street: Ur Enrich. Dwy **(OFFSET) - - -**

Year of Existing Counts 2016
Implementation Year **2016**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (Ur Enrich. Dwy)			Southbound (Ur Enrich. Dwy)		
Growth Rates	0.00%			0.00%			0.00%			0.00%		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	5	0	0	0	0	5	0	0	0	64	0	64
Subtotal (NO BUILD - A.M.)	***5***	***320***	***0***	***0***	***320***	***5***	***0***	***0***	***0***	***64***	***0***	***64***
Percent Office Trips Generated(Entering)	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent Office Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	157	0	0	40	0	0	0	0	0	0	0
Subtotal AM Pk Hr. BUILD Volumes	**5**	**477**	**0**	**0**	**360**	**5**	**0**	**0**	**0**	**64**	**0**	**64**
Pass-by Trip Adjustments	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total AM Peak Hour BUILD Volumes	**5**	**477**	**0**	**0**	**360**	**5**	**0**	**0**	**0**	**64**	**0**	**64**

	Eastbound (NM S.R. 176)			Westbound (NM S.R. 176)			Northbound (Ur Enrich. Dwy)			Southbound (Ur Enrich. Dwy)		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Existing Volumes	0	320	0	0	320	0	0	0	0	0	0	0
Background Traffic Growth	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	0	320	0	0	320	0	0	0	0	0	0	0
Uranium Enrichment Facility Trips	38	0	0	0	0	38	0	0	0	38	0	38
Subtotal (NO BUILD - P.M.)	***38***	***320***	***0***	***0***	***320***	***38***	***0***	***0***	***0***	***38***	***0***	***38***
Percent Office Trips Generated(Entering)	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Percent Office Trips Generated(Exiting)	*0.00%*	*0.00%*	*0.00%*	*0.00%*	***50.00%***	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Total Trips Generated	0	43	0	0	172	0	0	0	0	0	0	0
Subtotal PM Pk Hr. BUILD Volumes	**38**	**363**	**0**	**0**	**492**	**38**	**0**	**0**	**0**	**38**	**0**	**38**
Pass-by Trip Adjustments	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Total PM Peak Hour BUILD Volumes	**38**	**363**	**0**	**0**	**492**	**38**	**0**	**0**	**0**	**38**	**0**	**38**

	Entering	Exiting		
Number of CK Trips Generated	**314**	**79**	A.M.	100% Development
	86	**343**	P.M.	

HCM 2010 TWSC
3: NM 176 & Uranium Enrichment Driveway

Intersection	
Int Delay, s/veh	2.2

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations	↰	↑	↑	↱	↰↱	
Traffic Vol, veh/h	38	320	320	38	38	38
Future Vol, veh/h	38	320	320	38	38	38
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	500	-	-	780	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55
Mvmt Flow	45	376	376	45	45	45

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	376	0	-	0	842	376
Stage 1	-	-	-	-	376	-
Stage 2	-	-	-	-	466	-
Critical Hdwy	4.65	-	-	-	6.95	6.75
Critical Hdwy Stg 1	-	-	-	-	5.95	-
Critical Hdwy Stg 2	-	-	-	-	5.95	-
Follow-up Hdwy	2.695	-	-	-	3.995	3.795
Pot Cap-1 Maneuver	943	-	-	-	273	568
Stage 1	-	-	-	-	592	-
Stage 2	-	-	-	-	534	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	943	-	-	-	260	568
Mov Cap-2 Maneuver	-	-	-	-	260	-
Stage 1	-	-	-	-	592	-
Stage 2	-	-	-	-	509	-

Approach	EB	WB	SB
HCM Control Delay, s	1	0	18.4
HCM LOS			C

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	943	-	-	-	357
HCM Lane V/C Ratio	0.047	-	-	-	0.25
HCM Control Delay (s)	9	-	-	-	18.4
HCM Lane LOS	A	-	-	-	C
HCM 95th %tile Q(veh)	0.1	-	-	-	1

Intersection	
Int Delay, s/veh	3.7

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations	↰	↑	↑	↱	↰↱	
Traffic Vol, veh/h	5	320	320	5	64	64
Future Vol, veh/h	5	320	320	5	64	64
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	500	-	-	780	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55
Mvmt Flow	6	376	376	6	75	75

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	376	0	-	0	764	376
Stage 1	-	-	-	-	376	-
Stage 2	-	-	-	-	388	-
Critical Hdwy	4.65	-	-	-	7.65	6.75
Critical Hdwy Stg 1	-	-	-	-	6.65	-
Critical Hdwy Stg 2	-	-	-	-	6.65	-
Follow-up Hdwy	2.695	-	-	-	3.995	3.795
Pot Cap-1 Maneuver	943	-	-	-	264	568
Stage 1	-	-	-	-	550	-
Stage 2	-	-	-	-	542	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	943	-	-	-	263	568
Mov Cap-2 Maneuver	-	-	-	-	263	-
Stage 1	-	-	-	-	547	-
Stage 2	-	-	-	-	539	-

Approach	EB	WB	SB
HCM Control Delay, s	0.1	0	22
HCM LOS			C

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	943	-	-	-	360
HCM Lane V/C Ratio	0.006	-	-	-	0.418
HCM Control Delay (s)	8.8	-	-	-	22
HCM Lane LOS	A	-	-	-	C
HCM 95th %tile Q(veh)	0	-	-	-	2

Intersection	
Int Delay, s/veh	14.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		✥			✥	
Traffic Vol, veh/h	5	320	157	157	320	5	40	1	40	64	1	64
Future Vol, veh/h	5	320	157	157	320	5	40	1	40	64	1	64
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	500	-	500	500	-	780	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	85	85	85	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55	55	55	55	55	55	55
Mvmt Flow	6	376	185	185	376	6	47	1	47	75	1	75

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	376	0	0	376	0	0	1172	1134	376	1158	1134	376
Stage 1	-	-	-	-	-	-	388	388	-	746	746	-
Stage 2	-	-	-	-	-	-	784	746	-	412	388	-
Critical Hdwy	4.65	-	-	4.65	-	-	7.65	7.05	6.75	7.65	7.05	6.75
Critical Hdwy Stg 1	-	-	-	-	-	-	6.65	6.05	-	6.65	6.05	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.65	6.05	-	6.65	6.05	-
Follow-up Hdwy	2.695	-	-	2.695	-	-	3.995	4.495	3.795	3.995	4.495	3.795
Pot Cap-1 Maneuver	943	-	-	943	-	-	133	163	568	137	163	568
Stage 1	-	-	-	-	-	-	542	526	-	334	351	-
Stage 2	-	-	-	-	-	-	317	351	-	525	526	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	943	-	-	943	-	-	97	130	568	105	130	568
Mov Cap-2 Maneuver	-	-	-	-	-	-	97	130	-	105	130	-
Stage 1	-	-	-	-	-	-	539	523	-	332	282	-
Stage 2	-	-	-	-	-	-	220	282	-	477	523	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.1	3.2	53	87.5
HCM LOS			F	F

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	165	943	-	-	943	-	-	177
HCM Lane V/C Ratio	0.578	0.006	-	-	0.196	-	-	0.857
HCM Control Delay (s)	53	8.8	-	-	9.7	-	-	87.5
HCM Lane LOS	F	A	-	-	A	-	-	F
HCM 95th %tile Q(veh)	3	0	-	-	0.7	-	-	6.1

HCM 2010 TWSC
3: CK Drivewau/Uranium Enrichment Driveway & NM 176

01/25/2017

Intersection	
Int Delay, s/veh	99.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		✥			✥	
Traffic Vol, veh/h	38	320	43	43	320	38	172	1	172	38	1	38
Future Vol, veh/h	38	320	43	43	320	38	172	1	172	38	1	38
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	500	-	500	500	-	780	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	85	85	85	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55	55	55	55	55	55	55
Mvmt Flow	45	376	51	51	376	45	202	1	202	45	1	45

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	376	0	0	376	0	0	967	944	376	1046	944	376
Stage 1	-	-	-	-	-	-	466	466	-	478	478	-
Stage 2	-	-	-	-	-	-	501	478	-	568	466	-
Critical Hdwy	4.65	-	-	4.65	-	-	7.65	7.05	6.75	7.65	7.05	6.75
Critical Hdwy Stg 1	-	-	-	-	-	-	6.65	6.05	-	6.65	6.05	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.65	6.05	-	6.65	6.05	-
Follow-up Hdwy	2.695	-	-	2.695	-	-	3.995	4.495	3.795	3.995	4.495	3.795
Pot Cap-1 Maneuver	943	-	-	943	-	-	~ 188	215	568	165	215	568
Stage 1	-	-	-	-	-	-	488	483	-	480	476	-
Stage 2	-	-	-	-	-	-	466	476	-	425	483	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	943	-	-	943	-	-	~ 159	194	568	98	194	568
Mov Cap-2 Maneuver	-	-	-	-	-	-	~ 159	194	-	98	194	-
Stage 1	-	-	-	-	-	-	465	460	-	457	450	-
Stage 2	-	-	-	-	-	-	405	450	-	260	460	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.9	1	$ 339.4	49.5
HCM LOS			F	E

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	248	943	-	-	943	-	-	167
HCM Lane V/C Ratio	1.637	0.047	-	-	0.054	-	-	0.542
HCM Control Delay (s)	$ 339.4	9	-	-	9	-	-	49.5
HCM Lane LOS	F	A	-	-	A	-	-	E
HCM 95th %tile Q(veh)	25.7	0.1	-	-	0.2	-	-	2.8

Notes

~: Volume exceeds capacity $: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

HCM 2010 TWSC
3: NM 176 & Uranium Enrichment Driveway

01/25/2017

Intersection						
Int Delay, s/veh	3.7					

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations	↰	↑	↑	↱	Y	
Traffic Vol, veh/h	5	477	360	5	64	64
Future Vol, veh/h	5	477	360	5	64	64
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	500	-	-	780	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55
Mvmt Flow	6	561	424	6	75	75

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	424	0	-	0	997	424
Stage 1	-	-	-	-	424	-
Stage 2	-	-	-	-	573	-
Critical Hdwy	4.65	-	-	-	6.95	6.75
Critical Hdwy Stg 1	-	-	-	-	5.95	-
Critical Hdwy Stg 2	-	-	-	-	5.95	-
Follow-up Hdwy	2.695	-	-	-	3.995	3.795
Pot Cap-1 Maneuver	902	-	-	-	217	531
Stage 1	-	-	-	-	561	-
Stage 2	-	-	-	-	472	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	902	-	-	-	216	531
Mov Cap-2 Maneuver	-	-	-	-	216	-
Stage 1	-	-	-	-	561	-
Stage 2	-	-	-	-	469	-

Approach	EB	WB	SB
HCM Control Delay, s	0.1	0	27.5
HCM LOS			D

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	902	-	-	-	307
HCM Lane V/C Ratio	0.007	-	-	-	0.491
HCM Control Delay (s)	9	-	-	-	27.5
HCM Lane LOS	A	-	-	-	D
HCM 95th %tile Q(veh)	0	-	-	-	2.6

HCM 2010 TWSC
5: CK Driveway & NM 176

01/25/2017

Intersection						
Int Delay, s/veh	4.8					

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑	↱	↰	↑	Y	
Traffic Vol, veh/h	384	157	157	325	40	40
Future Vol, veh/h	384	157	157	325	40	40
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	500	500	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55
Mvmt Flow	452	185	185	382	47	47

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	452	0	1204	452
Stage 1	-	-	-	-	452	-
Stage 2	-	-	-	-	752	-
Critical Hdwy	-	-	4.65	-	7.65	6.75
Critical Hdwy Stg 1	-	-	-	-	6.65	-
Critical Hdwy Stg 2	-	-	-	-	6.65	-
Follow-up Hdwy	-	-	2.695	-	3.995	3.795
Pot Cap-1 Maneuver	-	-	878	-	126	511
Stage 1	-	-	-	-	497	-
Stage 2	-	-	-	-	331	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	878	-	106	511
Mov Cap-2 Maneuver	-	-	-	-	106	-
Stage 1	-	-	-	-	497	-
Stage 2	-	-	-	-	261	-

Approach	EB	WB	NB
HCM Control Delay, s	0	3.3	46.8
HCM LOS			E

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	176	-	-	878	-
HCM Lane V/C Ratio	0.535	-	-	0.21	-
HCM Control Delay (s)	46.8	-	-	10.2	-
HCM Lane LOS	E	-	-	B	-
HCM 95th %tile Q(veh)	2.7	-	-	0.8	-

HCM 2010 TWSC
3: NM 176 & Uranium Enrichment Driveway

01/25/2017

Intersection	
Int Delay, s/veh	2.4

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations	↰	↑	↑	↱	Y	
Traffic Vol, veh/h	38	363	492	38	38	38
Future Vol, veh/h	38	363	492	38	38	38
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	500	-	-	780	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	55	55	55	55	55	55
Mvmt Flow	45	427	579	45	45	45

Major/Minor	Major1		Major2		Minor2	
Conflicting Flow All	579	0	-	0	1095	579
Stage 1	-	-	-	-	579	-
Stage 2	-	-	-	-	516	-
Critical Hdwy	4.65	-	-	-	6.95	6.75
Critical Hdwy Stg 1	-	-	-	-	5.95	-
Critical Hdwy Stg 2	-	-	-	-	5.95	-
Follow-up Hdwy	2.695	-	-	-	3.995	3.795
Pot Cap-1 Maneuver	779	-	-	-	188	428
Stage 1	-	-	-	-	469	-
Stage 2	-	-	-	-	504	-
Platoon blocked, %		-	-	-		
Mov Cap-1 Maneuver	779	-	-	-	177	428
Mov Cap-2 Maneuver	-	-	-	-	177	-
Stage 1	-	-	-	-	469	-
Stage 2	-	-	-	-	475	-

Approach	EB	WB	SB
HCM Control Delay, s	0.9	0	27.2
HCM LOS			D

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	779	-	-	-	250
HCM Lane V/C Ratio	0.057	-	-	-	0.358
HCM Control Delay (s)	9.9	-	-	-	27.2
HCM Lane LOS	A	-	-	-	D
HCM 95th %tile Q(veh)	0.2	-	-	-	1.6

HCM 2010 TWSC
5: CK Driveway & NM 176

01/25/2017

Intersection	
Int Delay, s/veh	28.1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑	↱	↰	↑	Y	
Traffic Vol, veh/h	358	43	43	358	172	172
Future Vol, veh/h	358	43	43	358	172	172
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	500	500	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	85	85	85	85	85	85
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	421	51	51	421	202	202

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	421	0	943	421
Stage 1	-	-	-	-	421	-
Stage 2	-	-	-	-	522	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1138	-	291	632
Stage 1	-	-	-	-	662	-
Stage 2	-	-	-	-	595	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1138	-	278	632
Mov Cap-2 Maneuver	-	-	-	-	278	-
Stage 1	-	-	-	-	662	-
Stage 2	-	-	-	-	568	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.9	92.5
HCM LOS			F

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	386	-	-	1138	-
HCM Lane V/C Ratio	1.048	-	-	0.044	-
HCM Control Delay (s)	92.5	-	-	8.3	-
HCM Lane LOS	F	-	-	A	-
HCM 95th %tile Q(veh)	13.5	-	-	0.1	-

As of : 6/8/2016

Route	Traffic Sec id	Begin Mpnt	End Mpnt	DIR	FCLS	County Name	AADT 2015	AADT 2014	AADT 2013	Year	METH	Terminus	%HC
NM-176-P	8105	37.820	41.201	B	MJCL	LEA	4,257	4,662	2,800	2014	L	JCT NM 18.	54
NM-177-P	7761	0.000	0.640	B	MNCL	SIERRA	95	98	98	2011	L	JCT NM 51 EAST OF ELEPHANT BUTTE DAM, NORTH,	13
	25915	0.640	0.835	B			53	55	54	2011	L	JCT NM 195.	13
NM-179-P	7766	0.000	2.050	B	MJCL		998	1,036	1,025	2015	C	FROM JCT NM 51 NORTHWARD TO JCT NM 195 NORTHE	3
NM-181-P	7767	0.000	0.210	P			2,043	2,058	2,043	2011	L	JCT DATE ST. (LOOP 11) IN T. OR C. NORTHWARD	17
NM-181-M	7767	0.000	0.210	M			1,963	1,978	1,963	2011			17
NM-181-P	7767	0.210	0.410	B			4,006	4,036	4,006	2011	L		17
	7769	0.410	1.540	B			3,560	3,586	3,559	2011	L	JCT LOCAL ROAD NORTH OF TRUTH OR CONSEQUENCES	17
	25304	1.540	5.000	B			273	350	360	2015	C	JCT NM 171.	10
	19281	5.000	5.470	B			612	219	225	2015	C	JCT NM 195/I-25 NORTHBOUND RAMPS (EXIT 83).	12
	34083	5.470	7.500	B			583	521	536	2015	C	JCT I-25 SOUTHBOUND RAMPS (EXIT 83).	12
	19283	7.500	10.450	B			459	447	461	2015	C	JCT NM 52.	8
	25907	10.450	11.820	B			38	39	39	2011	L	JCT FR2028 WEST OF I-25 EXIT 89 (CUCHILLO INT	17
NM-182-P	7773	0.000	0.814	B		DONA ANA	2,027	1,735	1,784	2015	C	JCT. NM28 AT LA UNION, WEST TO END OF STATE M	9
	7773	0.814	1.306	B			2,027	1,735	1,784	2015	C		9
NM-183-P	16783	0.000	0.598	B			804	810	800	2015	C	FROM JCT. NM28 NORTH OF LA UNION, EAST TO THE	14
NM-184-P	7775	0.000	0.189	B	MNAR		8,154	8,217	12,663	2014	L	JCT. NM273 EAST TO NEW MEXICO/TEXAS STATE LIN	2
	7775	0.189	0.191	B			8,154	8,217	12,663	2014	L		2
	7775	0.191	0.567	B			8,154	8,217	12,663	2014	L		2
NM-185-P	7776	0.000	0.478	P	PRAR		7,681	7,619	7,658	2005	L	JCT US 70 IN LAS CRUCES, NORTH ON VALLEY TO J	12
NM-185-M	7776	0.000	0.478	M			8,175	8,110	8,152	2005			12
NM-185-P	18788	0.478	0.833	P			5,978	5,931	5,961	2012	L	JCT. MCCLURE ROAD (FL5567)	12
NM-185-M	18788	0.478	0.833	M			5,375	5,331	5,359	2012			12
NM-185-P	20966	0.833	0.990	P			4,919	4,447	4,469	2015	C	JCT HOAGLAND ROAD (FL5551).	10
NM-185-M	20966	0.833	0.990	M			4,855	4,284	4,306	2015			10
NM-185-P	20966	0.990	2.278	B			9,774	8,731	8,775	2015	C	JCT ISAACS LANE.	10
	7780	2.278	3.510	B			22,759	21,714	21,055	2009	L	JCT MYLES ROAD (CO. RD. D-19).	12
	20967	3.510	5.091	B			6,816	6,742	6,537	2015	C	JCT LOPEZ ROAD (13D018).	9
	16582	5.091	5.893	B			3,703	5,576	3,684	2015	C	JCT NM 320 (THORPE ROAD).	12
	16582	5.893	6.041	B			3,703	5,576	3,684	2015	C		12
	20968	6.041	8.371	B			2,270	2,241	2,261	2015	A	JCT RANCHO ALGODONES ROAD (13D039).	12
	7781	8.371	13.948	B	MJCL		1,912	2,117	2,178	2015	C	JCT NM 158.	12
	23958	13.948	30.407	B			960	586	603	2015	C	JCT NM 157.	10
	7788	30.407	34.411	B			689	677	696	2015	C	JCT NM 140.	12

Table 18.C-1
Access Spacing Standards for Intersections and Driveways

(centerline to centerline spacing in feet)

Access Category	Posted Speed (mph)	Intersection Spacing (feet) [1]		Driveway Spacing (feet) [2]		
				Non-Traversable Median		Traversable Median[4]
		Signalized	Unsignalized[3]	Full Access	Partial Access	
Controlled-Access, Non-Interstate Highways	All Speeds	5,280	2,640	2,640	2,640	-NA-
UPA	≤ 30 mph	2,640	1,320	1,320	200	200
	35 to 40 mph	2,640	1,320	1,320	325	325
	45 to 50 mph	2,640	1,320	1,320	450	450
	≥ 55 mph	5,280	1,320	1,320	625	625
UMA	≤ 30 mph	1,760	660	660	175	175
	35 to 40 mph	1,760	660	660	275	275
	45 to 50 mph	2,640	660	660	400	400
	≥ 55 mph	5,280	1,320	1,320	600	600
UCOL	≤ 30 mph	1,100	330	330	150	150
	35 to 40 mph	1,320	330	330	225	225
	45 to 55 mph	1,760	660	660	350	350
RPA	≤ 30 mph	2,640	1,320	1,320	225	225
	35 to 40 mph	2,640	1,320	1,320	350	350
	45 to 50 mph	5,280	2,640	2,640	500	500
	≥ 55 mph	5,280	2,640	2,640	775	775
RMA	≤ 30 mph	1,760	660	660	200	200
	35 to 40 mph	2,640	660	660	325	325
	45 to 50 mph	2,640	1,320	1,320	450	450
	≥ 55 mph	5,280	2,640	2,640	725	725
RCOL	≤ 30 mph	1,320	330	330	200	200
	35 to 40 mph	1,760	660	660	300	300
	45 to 50 mph	2,640	1,320	1,320	425	425
	≥ 55 mph	2,640	1,320	1,320	550	550

Notes:
1. Intersection - Public street or other access serving a large area or a major traffic generator(s) where full access is typically provided.
2. Driveway - Public or private access serving a limited area where traffic signal control is not required.
3. In urban areas, spacing should be consistent with the established street spacing along the state highway facility.
4. Includes highways with no median or a painted median. The type of access, full or partial, is determined at the discretion of the Department. See Sub-Sections 7.AO and 7.BP.

Table 17.B-3
Criteria for Left-turn Deceleration Lanes on RURAL TWO-LANE HIGHWAYS

Left-Turn Volume [1] (vph)	LEFT-TURN DECELERATION LANE			
	Minimum Directional Volume in Through Lane (vphpl) [2]			
	≤ 30 mph	35 to 40 mph	45 to 55 mph	> 55 mph
< 5	Not Required	Not Required	Not Required	Not Required
5	400	220	120	60
10	240	140	80	40
15	160	100	60	Required
20	120	80	Required	Required
25	100	Required	Required	Required
≥ 26	Required	Required	Required	Required

Left-turn Deceleration Lanes are Required on Rural Two-lane Highways for the following Left-turn Volumes:

- ≤ 30 mph : 26 vph or more
- 35 to 40 mph : 21 vph or more
- 45 to 55 mph : 16 vph or more
- > 55 mph : 11 vph or more

Notes:

1. *Use linear interpolation for left-turn volumes between 5 and 25 vph.*
2. *The directional volume in the through lane includes through vehicles and turning vehicles.*

Table 17.B-5
Criteria for Right-Turn Deceleration Lanes on RURAL TWO-LANE HIGHWAYS

Right-Turn Volume [1] **(vph)**	**RIGHT-TURN DECELERATION LANE**			
	Minimum Directional Volume in Through Lane (vphpl) [2]			
	≤ 30 mph	35 to 40 mph	45 to 55 mph	> 55 mph
< 5	Not Required	Not Required	Not Required	Not Required
5	800	460	270	160
10	430	280	170	110
15	290	180	110	80
20	200	140	90	70
25	170	120	80	Required
30	160	110	Required	Required
≥ 31	Required	Required	Required	Required

Right-turn Deceleration Lanes are Required on Rural Two-lane Highways for the following Right-turn Volumes:

- ≤ 30 mph : 31 vph or more
- 35 to 40 mph : 31 vph or more
- 45 to 55 mph : 26 vph or more
- > 55 mph : 21 vph or more

Notes:

1. *Use linear interpolation for left-turn volumes between 5 and 30 vph.*
2. *The directional volume in the through lane includes through vehicles and turning vehicles.*

K. **Speed Change Lanes:** Speed change lanes should be designed based on the following specifications. The criteria for determining the need for speed change lanes are described in Section 17. Schematic illustrations of speed-change lanes are included in Appendix E.

(1) **Length of Deceleration Lanes:** Deceleration lanes typically consist of three components: transition taper, deceleration distance, and queue storage. Each of these components are described below. Deceleration lanes should be designed so that a turning vehicle will develop a speed differential of 10 mph or less at the point it clears the through traffic lane. The length of the lane should allow the vehicle to come to a comfortable stop prior to reaching the end of the expected queue in the lane. Table 18.K-1 contains standard deceleration distances and transition tapers. Vehicle queue storage lengths are discussed in Paragraph 18.K.1.c.

Table 18.K-1
Deceleration and Acceleration Lengths (feet)

Speed Change Lane Condition	**Posted Speed (mph)**									
	25	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
Deceleration Distance										
Stop Condition	150	200	250	325	400	475	550	650	725	850
Slow to 15 mph	130	175	230	300	370	450	525	620	700	820
Deceleration Taper										
Length for 12-foot Lane	50	75	100	125	150	175	200	225	250	250
Straight Line Ratios (L:W)	4:1	6:1	8:1	10.5:1	12.5:1	14.5:1	16.5:1	18.5:1	21:1	21:1
Acceleration Lane Length	NA	190	270	380	550	760	960	1,170	1,380	1,590
Acceleration Taper										
Length for 12-foot Lane	NA	100	120	150	170	180	230	270	300	300
Straight Line Ratios (L:W)	NA	8:1	10:1	12.5:1	14:1	15:1	19:1	22.5:1	25:1	25:1

This table assumes level terrain and acceleration distances for the passenger car/pickup design vehicle. Refer to the text discussion of Sub-Section 18.K for additional guidance regarding the design of speed change lanes.

(a) **Transition Taper:** Deceleration tapers should be straight line tapers with rounded beginning and ending points. Deceleration taper lengths and ratios are provided in Table 18.K-1. Deceleration taper lengths do not require adjustment for grade. Exceptions to the deceleration tapers in Table 18.K-1 include:

i. On urban highways with posted speed limits between 45 mph and 55 mph, left-turn deceleration tapers may be designed using 300-foot radius/600-foot radius asymmetric reverse curve tapers according to the width of the speed-change lane and/or median.

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Highlights of Qualifications:

- *Supervisory & management experience in control and prevention of corrosion and* monitoring of environmental parameters.

Relevant Professional Experience:

URENCO USA (Jun 2012 – Present)

- Chemistry Services Manager
- Member of ASTM committees for D19 (Water) and C26 (Nuclear Fuel Cycle)
- Responsible for all environmental compliance activities on site

Xcel Energy (Oct 2010 – Present)

- *Manager, Nuclear Fleet Chemistry and Environmental Compliance.*
- Fleet groundwater protection program owner
- Chemistry and Environmental Liaison between Xcel nuclear and overall corporate

First Energy Nuclear Operating Corporation (Sep 2007 – Sep 2010)
Beaver Valley Power Station

- Chemistry Operations Supervisor
- Analysis of water chemistry for prevention of corrosion
- Environmental sampling activities / compliance with various environmental permits

Previous Positions

- Senior Scientist - Bechtel Bettis, Inc. (Sep 2005 – Sep 2007)
- Research Scientist – GEO-Centers, Inc. (Nov 2004 – Sep 2005)
  Center for Corrosion Science and Engineering, Naval Research Laboratory
- Graduate Research Assistant – University of Illinois at Urbana/Champaign (Aug 2000 – May 2004)
- Nuclear-qualified Petty Officer – US Navy (Dec 1988 – Sep 1997)

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Education and training

Ph.D. in Analytical Chemistry, UIUC Specialization in electrochemistry and surface science University of Illinois at Urbana / Champaign Prof. Andrzej Wieckowski, Dissertation Advisor	April, 2004
B.S. in Chemistry, Cum Laude, Chemistry Honors University of Wisconsin - Parkside	May, 2000

EVALUATION OF ENVIRONMENTAL CONCERNS WITH SITE LOCATION
C.K. DISPOSAL PERMIT APPLICATION
EUNICE, NEW MEXICO

by Matthew S McGovern, PhD
Chemistry Services Manager, URENCO USA

for Rodey Law
Albuquerque, New Mexico

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1. INTRODUCTION

Parkhill, Smith and Cooper has prepared a permit application titled: Lea County, New Mexico, C.K. Disposal E&P Landfill and Processing Facility (prepared by Parkhill, Smith & Cooper) to construct a waste recycling facility in Eunice, New Mexico. The C.K. Disposal (CKD) facility has been proposed to be located directly across the State Highway from URENCO USA and presents operational risks to the facility.

This report and the opinions expressed herein have been prepared by Dr. Matthew S. McGovern, Chemistry Services Manager of URENCO USA (UUSA). The scope of the analysis is as follows:

a. Review the permit application to evaluate the impacts of emission of sulfur-containing compounds on UUSA equipment and infrastructure.

b. Review the permit application for other potential site emissions that may have a deleterious effect on environmental conditions and equipment/infrastructure on the UUSA site.

2. BACKGROUND

I have reviewed the permit application for the proposed Facility, along with the supplemental materials provided under the New Mexico Inspection of Public Records Act ("IPRA") request. With respect to air emissions of sulfur-containing compounds, the supplemental analysis provided to the permit application (Parkhill, Smith & Cooper, September 2016) indicates that operation of this facility will result in an increase in background ambient air concentrations of those compounds at the UUSA facilities. The permit and supplemental materials do not address air emissions from the evaporation ponds designed to treat the Produced Water that is recovered following removal of the entrained oil and solids.

3. OPINIONS

Opinion 1: The operation of the oil reclamation plant has a high likelihood of adversely impacting UUSA operations due to failure of sensitive electronic components through increased corrosion rates as a result of release of sulfur-containing compounds upwind of the UUSA facility. This conclusion is based upon the information included in the application along with publicly available data characterizing the constituents included in the materials being processed.

My opinion is based on the following:

a) The application indicates that the facility is designed to treat and remove organic and corrosive constituents from Produced Water (PW) to make it marketable for reuse. The removal process includes evaporation ponds with mechanical aeration and a stripping tower. The application states that hydrogen sulfide and organic compounds will be emitted from multiple sources including the waste delivery, the stripping tower, the open working face of the landfill, and ponded water. (Reference 1) Of these constituents, hydrogen sulfide has been demonstrated to increase corrosion in copper and silver-based electronic circuitry. (Reference 2)

b) Models used in the supplemental information indicate that facility operation will result in increased concentrations of hydrogen sulfide at the UUSA facility by over 5 parts per billion at the UUSA building. (Reference 3)

c) UUSA has already experienced some electronic failures due to formation of copper sulfide dendrites on the components. These were attributed to concentrations of hydrogen sulfide and sulfur dioxide in the atmosphere. (References 4,5,6) Concentrations of the levels referenced in the above mentioned models have been shown to be sufficient for copper corrosion through testing performed by Purafil at the UUSA facility . (Reference 7)

d) The facility will service industrial trucks, predominantly powered by diesel engines, which emit sulfur dioxide as a byproduct of combustion. The application does not address such emissions. In the absence of analysis of the effect of truck exhaust on concentrations of sulfur dioxide at the facility, the potential for increasing corrosion of the electronics at the facility is unknown.

Opinion 2: The air dispersion of emissions material from the evaporation ponds was not evaluated in the application. The effect of having this type of facility upwind of UUSA would result in increased corrosion of UUSA equipment, infrastructure, and vehicles located downwind of the facility.

My opinion is based on the following:

a) The evaporation ponds at the facility are designed to evaporate the produced water that was treated in the initial step of oil recovery and treatment. Produced water from the Permian basin is a brine with corrosive constituents such as chlorides at concentrations ranging from 19750 mg/L to 75370 mg/L. (Reference 8)

b) The use of mechanical aeration will result in spreading salts to surrounding areas by atomizing the brine into small windborne droplets. Following evaporation, the remaining salt that is exposed on top of the soil will be left open to wind action. Common experience in the area demonstrates that dust and other particulates are often picked up and carried downwind. Exposure of metal structures, such as vehicles, to chloride and other salts will lead to corrosion of those structures.

c) Analysis of corrosion processes in sensitive electronics indicates that, in addition to sulfur-containing compounds, chloride is a primary contributor to corrosion rates in electronics. (References 10 & 11) The application does not address this issue. In the absence of analysis detailing the quantities of these salts carried by the wind, the potential for increasing corrosion of the electronics at the facility is unknown.

Opinion 3: Emission from the evaporation ponds located at the CK Disposal site would result in exceedances of parameters to the freshwater specifications of the UUSA discharge permit, specifically for the retention pond located on the south side of the facility (pond 1).

My opinion is based on the following:

a) The evaporation ponds at the facility are designed to evaporate the produced water that was treated in the Initial step of oil recovery and treatment. Produced water from the Permian basin is a brine with constituents such as chlorides at concentrations ranging from 19750 mg/L to 75370 mg/L, while the limits for fresh water are 250 mg/L. (References 8 and 9)

b) The use of mechanical aeration will result in spreading salts to surrounding areas by atomizing the brine into small windborne droplets. Following evaporation, remaining salt-covered soil will be left open to wind action. Common experience in the area demonstrates that dust and other particulate are often picked up carried downwind, depositing the chlorides and other compounds in the retention pond located on the south side of the facility. In the absence of analysis detailing the quantities of these salts carried by the wind, it can be expected that the salts would result in contaminating the water in the pond and exceeding the fresh water limits established by New Mexico Administrative Code to which UUSA is regulated.

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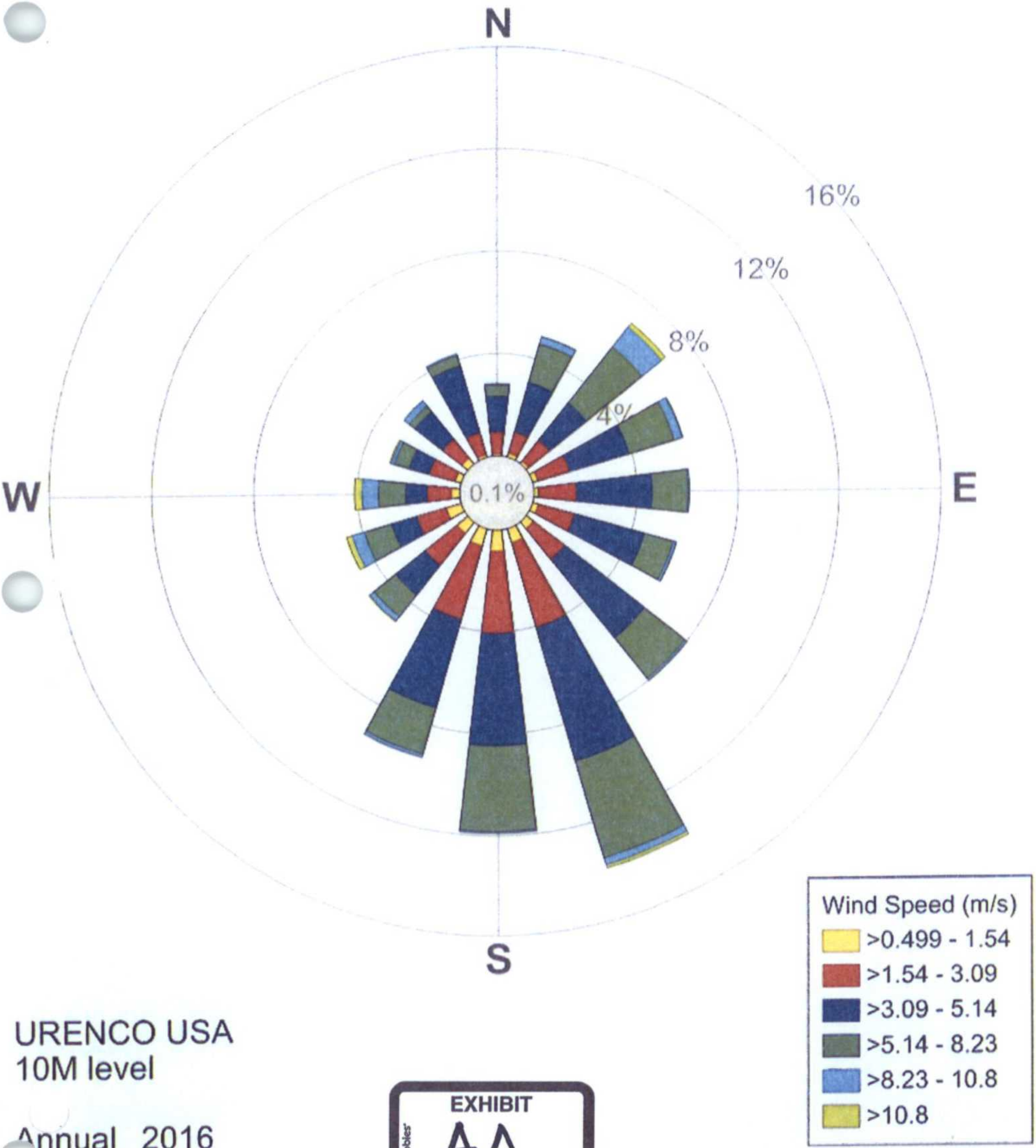

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Volatile-organic molecular characterization of shale-oil produced water from the Permian Basin

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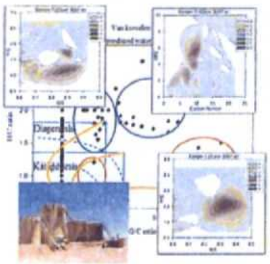
HIGHLIGHTS

- 1st high-resolution VOC MS data for the shale-oil produced water from Permian.
- Shale-oil water VOC high-resolution GC-ToF-MS identified 1400 compounds.
- 3D van Krevelen and DBE diagrams fingerprinting framework for high-resolution MS.
- Source composition & solubility controlled the composition of the produced water.
- Partial treatment may support beneficial reuse for fracturing or bio-energy.

GRAPHICAL ABSTRACT



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ABSTRACT

Growth in unconventional oil and gas has spurred concerns on environmental impact and interest in beneficial uses of produced water (PW), especially in arid regions such as the Permian Basin, the largest U.S. tight-oil producer. To evaluate environmental impact, treatment, and reuse potential, there is a need to characterize the compositional variability of PW. Although hydraulic fracturing has caused a significant increase in shale-oil production, there are no high-resolution organic composition data for the shale-oil PW from the Permian Basin or other shale-oil plays (Eagle Ford, Bakken, etc.). PW was collected from shale-oil wells in the Midland sub-basin of the Permian Basin. Molecular characterization was conducted using high-resolution solid phase micro extraction gas chromatography time-of-flight mass spectrometry. Approximately 1400 compounds were identified, and 327 compounds had a >70% library match. PW contained alkane, cyclohexane, cyclopentane, BTEX (benzene, toluene, ethylbenzene, and xylene), alkyl benzenes, propyl-benzene, and naphthalene. PW also contained heteroatomic compounds containing nitrogen, oxygen, and sulfur. 3D van Krevelen and double bond equivalence versus carbon number analyses were used to evaluate molecular variability. Source composition, as well as solubility, controlled the distribution of volatile compounds found in shale-oil PW. The salinity also increased with depth, ranging from 105 to 162 g/L total dissolved solids. These data fill a gap for shale-oil PW composition, the associated petroleomics plots provide a fingerprinting framework, and the results for

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the Permian shale-oil PW suggest that partial treatment of suspended solids and organics would support some beneficial uses such as onsite reuse and bio-energy production.

1. Introduction

Produced water (PW), as the largest waste stream generated during oil and gas production, is a mixture of formation water naturally present in reservoirs and water injected into reservoirs for pressure support, hydraulic fracturing, or reservoir treatment (Veil et al., 2004; Ahmadun et al., 2009). Understanding the sources and chemistry of formation waters is critical in oil-field management and petroleum exploration for many reasons such as planning for saltwater disposal and secondary recovery projects, proper treatment of production fluids to prevent corrosion and enhance phase separation (Ostroff, 1979). Also, predicting and locating variations in PW quality supports evaluating potential beneficial uses and treatment needs (Ahmadun et al., 2009).

Recent advances in horizontal drilling and hydraulic fracturing have caused a significant increase in unconventional hydrocarbon production including shale gas, coal-bed methane, tight oil, oil sands, and shale oil (Alley et al., 2011; Maguire-Boyle and Barron, 2014). Alley et al. found that PW compositions vary between each conventional and unconventional hydrocarbon production formation types (Alley et al., 2011). Orem et al. found that PW can be significantly altered from that of the formation for up to 250 days after hydraulic fracturing due to influence from compounds added during hydraulic fracturing (Orem et al., 2014), and Rowan et al. observed hydraulic fracturing flowback in PW from shale gas for up to 90 days (Rowan et al., 2015). Although compositions are highly variable, PWs contain dissolved inorganic salts (e.g. sodium, chloride, etc.), chemical additives used for drilling and well operations (e.g., hydraulic fracturing and/or corrosion inhibitor, biocide, and friction reducers), dissolved oil components (e.g. petroleum compounds), naturally occurring radioactive materials, suspended solids, and dissolved gases (Veil et al., 2004; Silset et al., 2010).

Several researchers have examined, to some extent, the organic composition within PW from various formations around the world (Utvik, 1999; Faksness et al., 2004; Sirivedhin and Dallbauman, 2004; Tellez et al., 2005; Lu et al., 2006; Dorea et al., 2007; Silset et al., 2010; Horner et al., 2011; Wang et al., 2012; Eftekhardadkhah and Oye, 2013; Maguire-Boyle and Barron, 2014; Orem et al., 2014). The composition and volume of PW varies as a function of the geologic formation and the age of the field (Dudasova et al., 2009). Tellez et al. used gas chromatography–mass spectroscopy (GC–MS) to evaluate PW from Permian Basin (Tellez et al., 2005). This work was conducted prior to the vast increases in unconventional oil production in the Permian, and there are no previously published investigations of PW from tight oil reservoirs within the Permian Basin, which is the most productive tight oil play in the US (Guerra et al., 2011). Recently, production in the Permian Basin has been >2 million barrels of oil per day (U.S.E.I.A., 2015). Despite use of GC–MS in several of these prior studies, the reported results focused on bulk trends in organic composition or on select compounds that could be separated and quantified. Wang et al. was the only paper that did use high-resolution MS and examined the complex mixture within PW from a conventional oil field in Wyoming using petroleomics analysis approaches including van Krevelen and double-bond equivalent (DBE) versus carbon number plots (Wang et al., 2012).

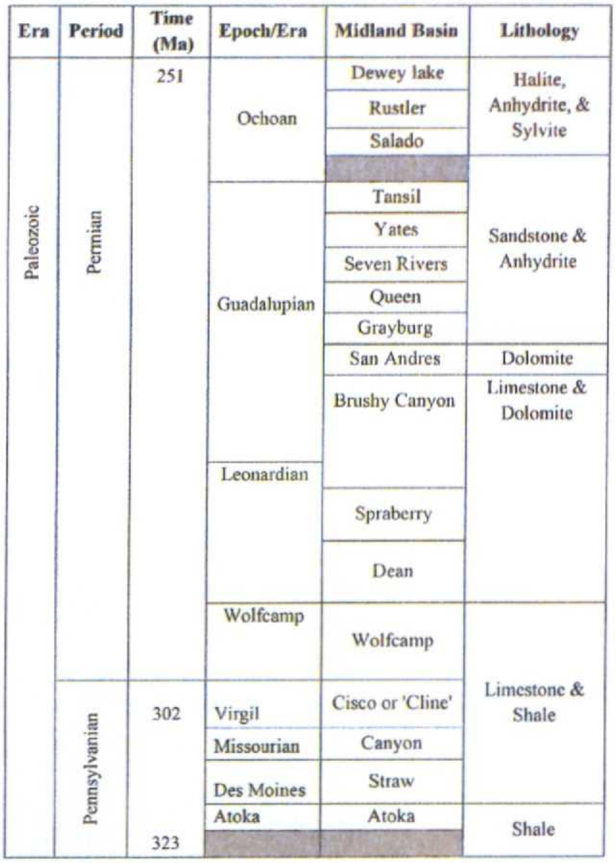
High-resolution GC–MS is critical for detailed organic-compositional fingerprinting and characterization of hydrocarbon mixtures. Gas chromatography-time of flight-mass spectroscopy (GC-ToF-MS) and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) are two of the few instruments that have been able to resolve the thousands of compounds in both crude oil and shale oil (Stanford et al., 2007; Avila et al., 2012; Cho et al., 2012, 2013; Jin et al., 2012; Kekalainen et al., 2013; Lababidi et al., 2013). The majority of this work used FT-ICR-MS for hydrocarbon analysis, whereas GC-ToF-MS has not been used as much even with its high-resolution capability for low polarity and nonpolar organic mixtures. Moreover, results plotted in van Krevelen diagrams have been typically used for oil maturation and source comparison (Kim et al., 2003; Wu et al., 2004), and they also appear well suited to amplify and expose compositional differences within and between complex organic mixtures such as PWs.

Despite prior work, there is still vast uncertainty in the molecular-level composition of PWs derived from unconventional hydrocarbon production formations. To our knowledge, no organic composition data are available from the unconventional shale-oil PW being produced from the Permian Basin or other shale-oil plays (Eagle Ford, Bakken, etc.). The goal of this study was to characterize the volatile organic compositional variability of late stage shale-oil PW from the Permian Basin using high-resolution GC–MS. Late stage PW, generally collected months or years after wells go into production is more indicative of the native formation water (Rowan et al., 2015), as opposed to analysis of early stage and flowback PW, which is particularly focused on the compounds used for hydraulic fracturing. Injected fracturing compounds are already reported for all wells in Texas through the FracFocus database. The organic compositional data for the PW samples was compared to the organic composition of oil and shale oil. Comparison of PWs quality with standards for drinking water was also used to examine beneficial use and treatment options.

2. Materials and methods

2.1. Permian Basin hydrogeology

The Permian Basin province, containing multiple sub-basins located in western Texas and eastern New Mexico, is one of the most productive hydrocarbon plays within North America, containing conventional oil, tight oil, and natural-gas resources (Guerra et al., 2011). Due to the depositional history, there are significant variations in lithology, geochemistry, and hydrologic properties of the hydrocarbon reservoirs. Fig. 1 presents the stratigraphic column of Midland Basin within the Permian Basin with the lithologic setting. At their deepest points the two sub-basins, the Midland and Delaware Basins, contain approximately 4600 m and 10,700 m of sediments, respectively, overlying Precambrian basement. Pre-Pennsylvanian strata that consist primarily of those contained in the precursor to the Permian Basin, the Tobosa Basin, are composed of marine carbonates and shales. Permian-age sediments include a sequence of geologic strata including evaporites, carbonates, discontinuous fluvial-deltaic arkosic sandstones, very fine siltstone and marine shales (Fig. 1). Historically, much of the hydrocarbon production was derived from conventional structural and stratigraphic traps in Guadalupian and Leonardian age reservoirs



Era	Period	Time (Ma)	Epoch/Era	Midland Basin	Lithology
Paleozoic	Permian	251	Ochoan	Dewey lake	Halite, Anhydrite, & Sylvite
				Rustler	
				Salado	
					Sandstone & Anhydrite
			Guadalupian	Tansil	
				Yates	
				Seven Rivers	
				Queen	
				Grayburg	
				San Andres	Dolomite
				Brushy Canyon	Limestone & Dolomite
			Leonardian		
				Spraberry	
				Dean	
			Wolfcamp	Wolfcamp	Limestone & Shale
	Pennsylvanian	302	Virgil	Cisco or 'Cline'	
			Missourian	Canyon	
			Des Moines	Straw	
			Atoka	Atoka	Shale
		323			

Fig. 1. Generalized stratigraphy of the Paleozoic Era across the Permian Basin [Modified from Bassett and Bentley and Dutton et al. (1982, 1987)].

(Dutton et al., 2005). More recently, with the advent of horizontal drilling and slick water hydraulic fracturing, low permeability, organic-rich source rocks in the Leonardian (e.g., Spraberry, Bone Spring, Avalon, etc.), Wolfcampian (i.e., Upper, Middle, and Lower Wolfcamp shales), and Pennsylvanian (e.g., "Cline" shale) age reservoirs have been targets for production. Above the hydrocarbon-bearing reservoir rocks of the Permian Basin, there is an evaporite layer (primarily anhydrite and halite) overlain by fluvial, deltaic, and lacustrine deposits of the Triassic Dockum Group and the Neogene Ogallala (Senger et al., 1987). Geochemical investigation of PWs, particularly those thought to represent the native formation brines present in the reservoirs prior to hydrocarbon production, can provide a broad spectrum of information about the history, origin, and geology of the basin and its fluids. Recent work by Engle and Blondes (Engle and Blondes, 2014) has evaluated the brine geochemistry of the Guadalupian-age Permian Basin formations. Thus, PW brine chemistry is not discussed herein.

2.2. Sample collection

PW samples were collected from oil-producing wells in Texas (i.e., Midland Basin). The PW samples were collected from 8 different wells that were producing from the Wolfcamp Shale ormation, except for sample 1 which had a producing depth that extended into the 'Cline' Shale Formation below the Wolfcamp (Table 1). The total thickness of the stratigraphic subset sampled and examined for this study was 1892–2163 m below land surface of the Midland sub-basin of the Permian Basin. All samples had average temperature of 31 °C, and pH was 8 on average. There were 6 samples collected directly from the wellhead, and 2 samples were collected from the oil-water separators adjacent to the wellhead. Samples were collected during production approximately 130–441 days after hydraulic fracturing, and thus they tend to represent the native formation waters rather than compounds involved with hydraulic fracturing. Samples were collected without any headspace in 4-L amber glass volatile organic analysis (VOA) vials, which were previously washed with distilled-deionized water and oven dried. Additional sampling, including replicates, to support an ongoing inorganic and isotopic chemistry investigation was also conducted.

2.3. Chemical analysis

All samples were refrigerated at 4 °C (<1 month), and then placed on a bench top for 24 h to settle suspended solids and oil droplets prior to sampling. Then a 10 mL pipette was used to collect samples from the water phase. Dilution (10×) with distilled-deionized nanopure (Series 550, Barnstead Thermolyne Corp., Dubuque, Indiana) water was required to meet the linear analysis response range. A standard mixture of benzene, toluene, ethylbenzene and xylene (BTEX) and fifteen other volatile compounds (Chem Service, Inc; model # VOC-1N; Serial # 93-112778) with a concentration of 20 mg/mL of each component was prepared from the pure analytes by weight in methanol (Merk, Darmsradt, Germany). A 1 mg/L standard solution of BTEX and fifteen other volatile compounds was prepared from the pure analytes (Merck). Finally, 20 μL Anthracene-D10 (Restek, Catalog # 31037) was spiked in 1 mg/L standard solution as internal standard, which was used for calculating response factors of those standard chemicals.

A CTC Analytics (Switzerland) CombiPAL autosampler fitted with a 100 μm polydimethylsiloxane (PDMS) solid phase micro extraction (SPME) fiber was used to collect and deliver samples. Each sample was incubated for 5 min at 45 °C, and then sampled for 5 min. After sampling, the fiber had a 10 min desorption time in the injector, which was fitted with a septaless Merlin Microseal. For analyzing organic compounds in PW, GC-ToF-MS was used with a modified Petroleum Refinery Reformate method. Injections were made on a 7890A Agilent Gas Chromatograph fitted with a ZB-5MS column (30 m, 0.25 mm I.D., 0.25 μm film thickness) with helium as the carrier gas. A solvent delay of 0.1 min was used. The inlet was in splitless mode with a constant flow of 0.6 mL/min for the entire run, and a front inlet septum purge of 3 mL/min. The inlet was operated at a constant 225 °C and the transfer line was constant at 275 °C. The oven program started at 35 °C, held for 4 min, ramped to 110 °C at 5 °C/minute, ramped to 280 °C at 7 °C/minute, and held for 0.5 min. A Leco Pegasus High Throughput Time of Flight Mass Spectrometer detector was used for all GC–MS analyses. We collected masses from 55 to 550 m/z with an acquisition rate of 20 spectra/second operating at 1800 V, and the ion source was heated at 210 °C. ChromaTof version 4.41 was used for data processing with automatic smoothing, 1.5 s peak width, baseline subtraction just through the middle of the noise, and automatic mass spectral deconvolution and peak detection at 100:1 signal to noise ratio.

Subsamples from the 8 samples were mixed uniformly (5 mL from each sample) into 40 mL. Then 5 mL subsample of that mix was diluted with 5 mL of nanopure water in 20 mL SPME vials spiked with Anthracene-D10, which was then analyzed with GC-ToF-MS for creating an Ion file assumed to be representative for all samples. This Ion file was used for aligning all ions in all PW samples in a common file with Met Idea software. Then the compounds with 70%, or greater, match to the National Institute of Standard and Technology (NIST) library were considered for the

Table 1
Produced water sample summary and analysis results for total dissolved solids (TDS), total suspended solids (TSS), total organic carbon (TOC), and dissolved organic carbon (DOC).

Sample ID	Sedimentary formation	Sampling location	Sample time after fracturing (days)	Sample depth (meter)	TDS (mg/L)	TSS (mg/L)	TOC (mg/L)	DOC (mg/L)
Sample 1	Wolfcamp	Wellhead	151	1892	106,540	6850	86.25	63.45
Sample 2	Wolfcamp	Separator	412	1914	113,760	16,330	123.71	127.09
Sample 3	Wolfcamp	Wellhead	403	1928	116,370	7410	173.33	145.71
Sample 4	Wolfcamp	Wellhead	366	1972	105,030	9110	90.6	82.83
Sample 5	Wolfcamp	Wellhead	411	1978	119,083	12,060	164.34	98.27
Sample 6	Wolfcamp	Wellhead	418	2055	114,830	18,720	139.74	112.11
Sample 7	Cline	Wellhead	441	2057	162,880	20,560	142.84	99.8
Sample 8	Wolfcamp	Separator	130	2163	142,630	21,820	184.21	139.66

rest of the analysis. Response factors for all standards with the internal standards were calculated as the ratio of the product of the compound area and internal standard concentration divided by the product of the internal standard area and compound concentration. The response factors were used for calculating concentration and relative concentration of organic compounds in PW samples. Peak abundances for all compounds were normalized based on the anthracene-D10 peak area, and then the abundance of the internal standard peak was used to normalize the abundance of other peaks (Cho et al., 2013). A surrogate for concentration, relative abundance was determined for all compounds not included in the volatile compound external standard mixture (Chem Service, Inc; model # VOC-1N; Serial # 93-112778). The relative abundance of each individual compound was calculated as the normalized peak area divided by the sum of all normalized peak areas (as %). Double bond equivalence (DBE) represents the number of rings plus the number of double bonds in a given molecular formula. DBE values were calculated using Equation (1) from Cho et al. (2013).

Total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS) were measured gravimetrically after heating in an oven (VWR-1370 FM). Standard Methods 2540 C method was used for TDS measurement. Total Organic Carbon Analyzer (Simadzu TOC-L, Kyoto, Japan) was used for analyzing total carbon and inorganic carbon in each PW sample. Samples were centrifuged before measurement of total organic carbon (TOC) and filtered by 0.45 μm cellulose acetate membrane (Toyo Roshi Kaisha, Ltd., Japan) before measurement of dissolved organic carbon (DOC). Subsamples were filtered and preserved with 2% nitric acid before inductively coupled plasma-optical emission spectrometer (ICP-OES) cation analysis, and anions were evaluated with ion chromatography and technical auto analyzer (data not shown). Acumen pH/Specific Ion Meter Model 25 was used for measurements of bicarbonate and alkalinity by titration (Franson, 1992).

3. Results and discussion

3.1. Produced water quality

The results of late stage shale-oil PW sampling and analysis from the shale-oil producing units in the Permian fill an important data gap for organic composition data, which to our knowledge have not previously been available for unconventional shale-oil PW being produced from the Permian Basin or other important shale-oil plays (Eagle Ford, Bakken, etc.), which have experienced tremendous production increases recently due to hydraulic fracturing. The shale-oil PWs samples exhibited significant compositional variability, and generally elevated (compared to fresh water and most shallow groundwater used for hydraulic fracturing) concentrations of salts and organic compounds (Table 1). Fresh groundwater was used for hydraulic fracturing, and flowback after fracturing is a mixture of fresh water and formation brine until flowback has been removed and only formation water remains in the PW. TDS values in Table 1 are all approximately a factor of 3 larger than sea water, and they are generally higher than the diluted PW observed during fracturing flowback, which suggests that the samples are representative of the formation and not impacted by fracturing operations. This was confirmed by examination of replicate sample isotope results (data not shown). Fig. 2 presents TDS, TSS, DOC, and TOC as a function of formation depth below land surface, which generally indicates increasing values for each parameter with depth over the section investigated. The sampled shale-oil PWs had a large salinity (TDS) range of 105–162 g/L, and concentrations of TOC and DOC were less variable. The mean values for TDS, TSS, TOC, and DOC were 122,640, 14,107, 138, 109 mg/L, respectively. Sirivedhin and Dallbauman (2004) measured the DOC range of 9–13 mg/L for oil-PW from Oklahoma, and Wang et al. (2012) measured 15 mg/L DOC for oil-PW from Wyoming. TOC values reported for PW from shale-gas can be significantly higher than the values reported from this study, and TOC values for coal bed methane PW are typically lower than those we report for shale-oil PW (Maguire-Boyle and Barron, 2014; Orem et al., 2014). Many oil-formation PWs typically have TDS values up to 1 or 2 g/L (Dorea et al., 2007; Horner et al., 2011), whereas Sirivedhin and Dallbauman (2004) reported >70–100 g/L for the range of oil-PW TDS values. The known range for TDS of PWs in Permian basin is ~100–300 g/L (Guerra et al., 2011). These results suggested that PW derived from the oil-bearing shale formations were sourced from partially evaporated paleo-seawater while PW derived from shallower formations consist of meteoric water that dissolved halite and anhydrite (Engle and Blondes, 2014).

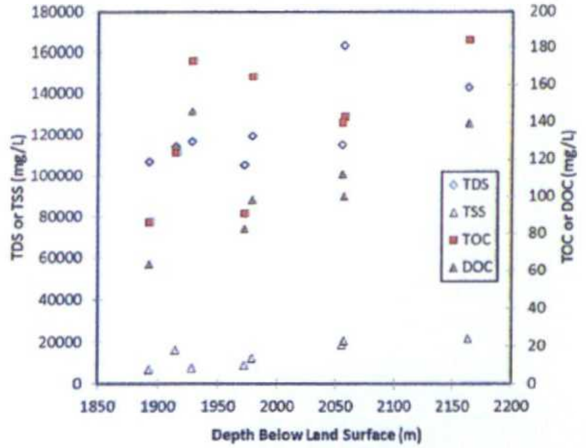


Fig. 2. Comparison of total dissolved solids (TDS), total organic carbon (TOC), and dissolved organic carbon (DOC) as a function of depth below land surface.

3.2. *Quantitative organic composition*

Approximately 1400 organic chemicals were identified with peak separation and deconvolution, and approximately 300–400 of these compounds had identifiable structures. These results suggest that PW from oil-bearing shale formations may be one of the most complex mixtures identified in water, and that there is a vast suite of volatile and semi-volatile organic compounds that dissolve into water from shale-oil formations. Even though many had uncertain structures, there were 327 compounds with structures identified with confidence (70% or greater match with NIST library), which were extracted by processing chromatograms with Met-Idea software by aligning all ions in a common file. The Anthracene-D10 spike was used to quantify relative abundance for the 327 compounds in each of the samples. Detection of volatile organic compounds by SPME is impacted by the "salting-out effect" where the transfer to gas from aqueous phase becomes increased by increasing the ionic strength of the aqueous phase (Lambropoulou and Albanis, 2001). Generally, the addition of salt is thought to increases the sensitivity of the hydrophobic compounds, and the extraction and detection of volatile organic compounds was most likely enhanced for PW samples compared to fresh water samples.

A subset of the 327 compounds was evaluated using the internal and external standards for quantification of aqueous concentration. Table 2 presents eight identified compound classes in the shale-oil PWs along with their concentration, which included the BTEX compounds that are typically considered for health and toxicity concerns. These results illustrate the compositional variability observed within shale-oil PW. For example, the concentration range for benzene nearly spans 3 orders of magnitude, and even the mean concentration of 107 mg/L for benzene is greater than four orders of magnitude higher than the maximum contaminant level (MCL) for drinking water in the U.S. Reported benzene composition within PW from oil-formations varies in the range of 1–4 mg/L (Utvik, 1999), 0.03–0.1 mg/L (Sirivedhin and Dallbauman, 2004), 1.4 mg/L (Dorea et al., 2007), and 0.026 mg/L (Horner et al., 2011), which are 1–4 orders of magnitude lower than the mean reported here for shale-oil PW. Although these compounds are generally considered volatile and biodegradable, their toxicity suggests that treatment of these chemicals may be required prior to many of the potential beneficial use or reuse alternatives (Veil et al., 2004; Xu et al., 2008a, 2008b; Graham et al., 2015).

3.3. *Hydrocarbon classes*

Most oil and gas PWs primarily contain cyclohexane, cyclopentane, alkanes, polyaromatic hydrocarbons, and heteroatomic compounds (Orem et al., 2014). The most prevalent group in shale-oil PW is straight chain alkanes based on the Permian Basin shale-oil PW samples evaluated herein. Fig. 3 presents relative abundance of hydrocarbon classes (cyclohexane, cyclopentane, n-alkanes) from lower to higher concentration trend (i.e., relative abundance) for each of the shale-oil PW samples from the Permian Basin. Among all hydrocarbons, straight chain alkanes (C_nH_{n+2}) are the major compound class contributing to the TOC (Fig. 3) from all samples examined in this study though their relative abundance did exhibit a wide range of variability. Alkanes were also found as the most dominant organic group in a PW sample from a prior study conducted in the Permian Basin (Tellez et al., 2005). The trend observed in Fig. 3 was also comparable to the results published on oil-gas cuts [petroleum oil fraction obtained by molecular distillation from crude oil]. For example, Avila et al. also found the same trend, and comparable relative concentrations, for oil-gas cuts (Avila et al., 2012). This suggests that source-oil composition has a significant impact on PW hydrocarbon composition.

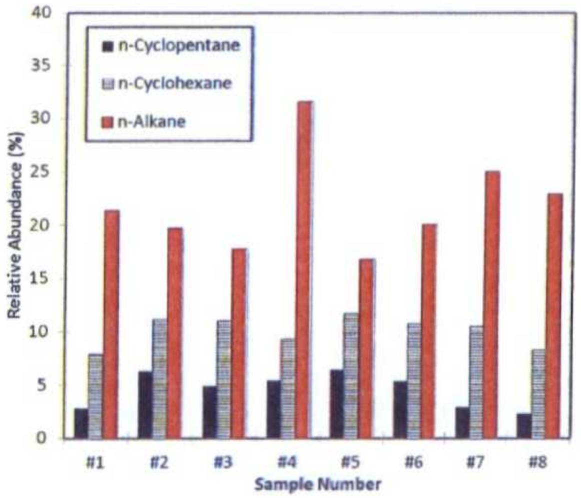


Fig. 3. Comparison of alkane, cyclohexane and cyclopentane relative abundance in PW samples. The sample numbers are ordered by increasing depth from left to right.

Both alkanes and heteroatomic hydrocarbon groups have been identified within the shale-oil PW samples from the Permian Basin. Among all heteroatomic compounds detected and matched, nitrogen and oxygen containing hydrocarbons are dominant, and only two sulfur-containing compounds had a structure match (>70%). However, many other sulfur, nitrogen, and oxygen containing compounds have been identified with a <70% library match.

Table 2

Summary of benzene, toluene, ethylbenzene, and xylene (BTEX) compound concentrations (mg/L) and statistics.

Sample ID	Alkyl propo-benzene	Alkyl benzene	Chloro-benzene	Alkyl naphthalene	BTEX			
					Benzene	Toluene	p-Xylene	Ethylbenzene
Sample 1	9.34	74.63	0.02	0.67	1.50	0.11	0.02	2.01
Sample 2	38.12	427.80	0.10	1.12	8.93	0.67	0.25	28.11
Sample 3	13.45	130.63	0.04	0.38	5.87	0.41	0.05	7.94
Sample 4	209.15	5092.60	0.03	4.20	778.51	5.61	0.01	399.84
Sample 5	79.77	917.80	0.19	1.32	45.55	3.03	0.46	81.78
Sample 6	35.80	384.88	0.04	1.13	6.25	0.46	0.14	27.87
Sample 7	94.59	1751.03	0.35	1.68	7.82	2.12	0.25	29.18
Sample 8	14.97	175.43	0.04	1.15	4.14	0.10	0.03	4.12
Average	61.90	1119.35	0.10	1.46	107.32	1.56	0.15	72.61
Minimum	9.34	74.63	0.02	0.38	1.50	0.10	0.01	2.01
Maximum	209.15	5092.60	0.35	4.20	778.51	5.61	0.46	399.84
Standard deviation	67.22	1698.91	0.11	1.18	271.57	1.94	0.16	134.63

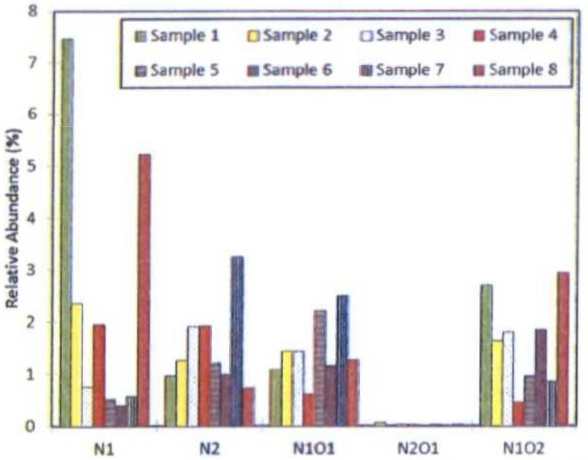


Fig. 4. Comparison of heteroatomic compound class as relative abundance in PW samples. The sample numbers are ordered by increasing depth from left to right.

Fig. 4 presents the relative abundance of heteroatomic compounds as a function of the chemical classes for each of the shale-oil PW samples. Overall, the N_1, N_2 and N_1O_1 classes were more abundant compared to N_3, N_3O_1 classes, which was also the same trend observed in oil-shale pyrolysates chemical analysis (Jin et al., 2012; Cho et al., 2013). This observation suggests that shale-oil PW and oil-shale pyrolysates have similar heteroatom compositions, which supports the observation that source-oil composition has a significant impact on PW composition. The comparison of source oil and PW composition may be especially favorable for heteroatom compounds, which tend to be more polar and soluble. An exception in this comparison is observed for N_2O_1 and N_1O_2. For the PW results, N_2O_1 is less than N_1O_2 whereas, in shale oil composition, N_1O_2 was less than N_2O_1 containing compounds. This discrepancy may be analytical, because electrospray ionization FT-ICR-MS is more sensitive for detection of polar compounds compared to GC-ToF-MS (Zhou et al., 2012).

3.4. Van Krevelen analysis

Van Krevelen diagrams, cross-plots of atomic hydrogen:carbon (i.e., H/C) as a function of oxygen:carbon (i.e., O/C) for all the measured hydrocarbons, can be used for hydrocarbon thermal maturation evaluation, and may also support organic mixture characterization and forensic analysis. The analysis for the shale-oil PW samples from the Permian Basin suggests both Type I (Lacustrine) and Type II (Marine) source rock, and it also suggests diagenetic source-rock alteration supported shale-oil formation. This is reasonable for the Wolfcamp, because there has been almost complete conversion of smectite to illite, suggesting that clay mineral diagenesis was nearly complete. For the van Krevelen evaluation presented herein, H/C was plotted both as a function of O/C and N/C, and comparison of concentration variability was examined by addition of contours of relative abundance. These plots compare the alkene to heteroatomic abundance distribution. Progression to increased H/C and N/C values follows with increasing degree of unsaturation (Cho et al., 2013).

Fig. 5 contains the 3D van Krevelen diagrams for each of the shale-oil PW samples with O/C on the x-axis and relative abundance (%) contours. Comparison of these figures suggests that there are significant deviations between the overall magnitude of volatile organic compound abundance, or concentration, as confirmed by the change in the plot scales, and spatial patterns within the figures confirm the variability between samples for the spectrum of compound abundances. Despite these observations, there are similarities and trends that can be detected. The overall range of abundance generally increases with depth until the two deepest samples.

There are several peaks and areas of elevated abundance compared to the background. Table 3 lists the names and formulas of the major abundance peak compounds observed in the van Krevelen diagrams. There is an abundance peak at H/C 1.2 and O/C 0.1 present in samples 1, 2, 3, 5, 6, 7, and 8 (missing from 4), which is 1-(2,4-dimethylphenyl)-ethanone ($C_{10}H_{12}O$). There is another area of abundance observed in three of the deeper samples (i.e., 5, 6, and 7), that covers H/C 1–1.4 and O/C 0.15–0.4, which is represented by compounds such as 1-(2-furanyl)-3-butene-1,2-diol ($C_8H_{10}O_3$). Another peak at H/C 1.7 and O/C 0.3 is not present in any of the samples except the two deepest samples (i.e., 8 and 7), which is acetyl valeryl ($C_7H_{12}O_2$). These results are similar to the van Krevelen results for PW from conventional oil production in Wyoming, which ranged from H/C 0.5–2.4 and O/C 0–0.8 (Wang et al., 2012). Wang et al. also noted that the peak at H/C 1.2 and O/C 0.1 tended to be condensed hydrocarbons, and lipids occur at H/C ~1.8 and O/C ~0.2.

Fig. 6 presents the 3D van Krevelen diagrams for each of the PW samples with N/C on the x-axis and relative abundance (%) contours. As was observed from the O/C plots, the N/C plots also illustrate the compositional variability and complexity of the shale-oil PW samples, and there is also a trend of increasing abundance with depth. One prominent feature is the abundance peak around H/C of ~1.7 and N/C of ~0.3. This peak increases in size and abundance with depth and varies based on compositional fluctuations of compounds such as butanenitrile (C_4H_7N), cyanic acid propyl ester (C_4H_7NO), and 1,4-dimethyl-2,3-diazabicyclo[2.2.1]hept-2-ene ($C_7H_{12}N_2$). The efficacy of Figs. 5 and 6 for characterizing trends in such complex mixtures suggests that petroleomics fingerprinting methods such as 3D van Krevelen plotting can be used to characterize PW from oil and gas production including shale-oil.

3.5. Double bond equivalence analysis

Fig. 7 presents the 3D cross-plots of DBE as a function of carbon number with relative abundance (%) contours for each of the PW samples. As was observed from the 3D van Krevelen diagrams, the 3D DBE plots also illustrate the compositional variability and complexity of the shale-oil PW samples. However, the DBE plots focus primarily on the aromaticity of conjugated cycloalkenes within the mixtures. It is also evident from these plots that a number of peaks in abundance can be observed, and Table 3 also listed the names of the peak compounds. The area of abundance within plots for samples 1 and 3 along the upper border is typical for multi-ring polycyclic aromatic hydrocarbons (PAHs) such as phenanthrene (i.e., $C_{14}H_{10}$). The two neighboring peaks in the center of the sample 3 plot at DBE 7 – C 11 and DBE 7 – C 14 are represented by 2-methyl-naphthalene ($C_{11}H_{10}$) and 1,4,5,8-tetramethylnaphthalene ($C_{14}H_{16}$), respectively. Another peak, just below at DBE 4 or 5 – C 10 is represented by 1-methyl-3-propylbenzene ($C_{10}H_{14}$) and 1-(2,4-dimethylphenyl)-ethanone ($C_{10}H_{12}O$). The peak at DBE 2 – C 4, butanenitrile (C_4H_7N), is missing from sample 6 and prominent in samples 1, 2, 4, 5, 7, and 8. This peak is adjacent to another peak in samples 5 and 7, but they are separated by a difference in carbon number. This other peak is located at DBE 2 – C 7, which is represented by 3-methylcyclohexene (C_7H_{12}). In deeper samples 3, 4, 5, and 7, additional peaks at DBE 3 – C 6 and DBE 4 - C 6 develop, which are due to 2-methoxyfuran ($C_5H_6O_2$) and benzene C_6H_6. These results are similar to the DBE results for

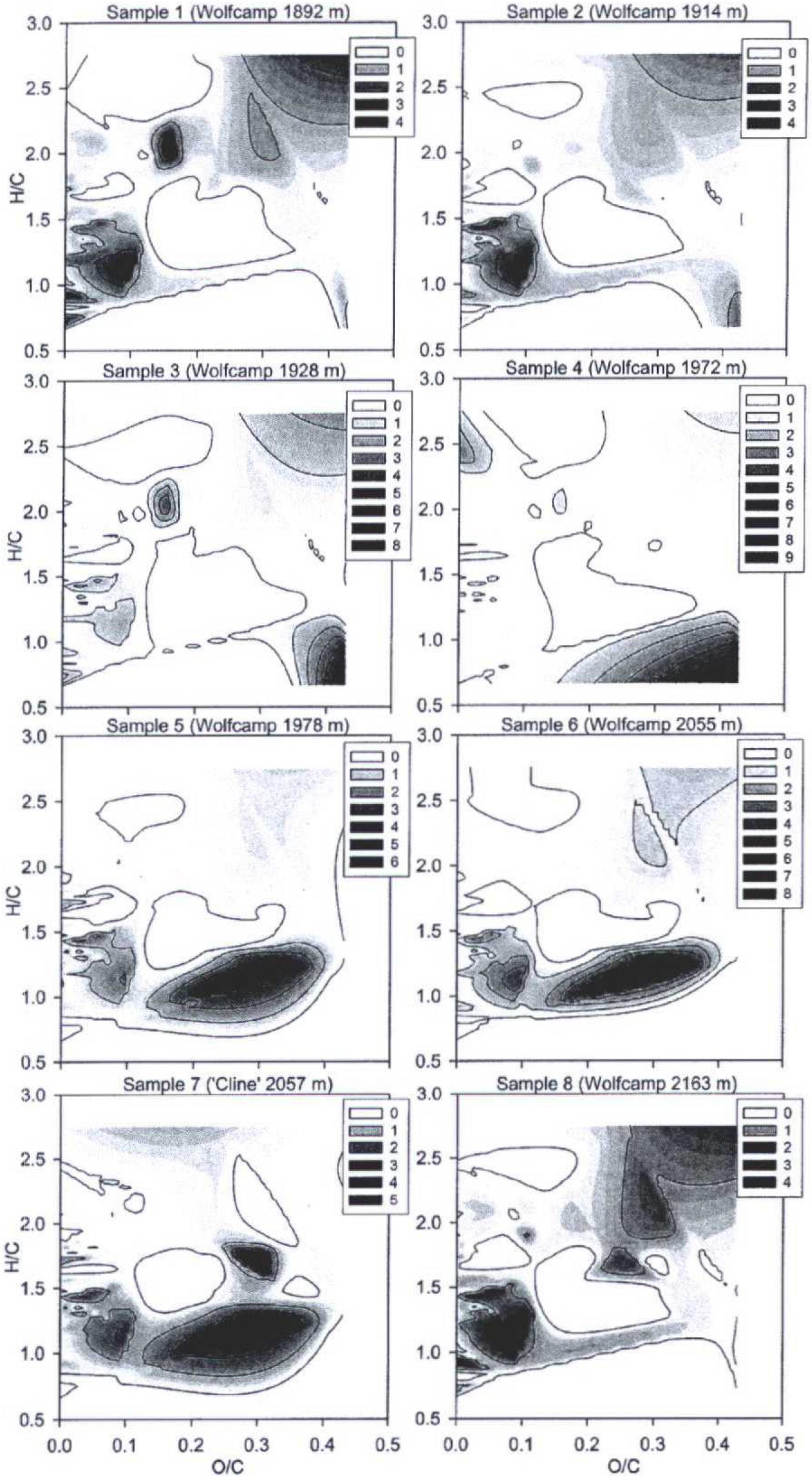


Fig. 5. Comparison of 3D van Krevelen (H/C versus O/C) with relative abundance (%) contours. Plots increase in sampled formation depth from left to right and top to bottom.

Table 3
Summary of abundance peak compounds (and their molar ratios) identified on van Krevelen and double-bond equivalent (DBE) versus carbon plots.

H/C	O/C	Compound name	Formula	CAS
2.8	0.3	Hydroxylamine, O-(2-methylpropyl)	$C_4H_{11}NO$	5618-62-2
2.3	0.1	Nitroxide, bis(1,1-dimethylethyl)	$C_8H_{18}NO$	2406-25-9
1.2	0.1	Ethanone, 1-(2,4-dimethylphenyl)-	$C_{10}H_{12}O$	89-74-7
2.4	0.0	Pentane	C_5H_{12}	109-66-0
1.3	0.4	3-Butene-1,2-diol, 1-(2-furanyl)	$C_8H_{10}O_3$	19261-13-3
1.4	0.0	Benzene, 1-methyl-3-propyl-	$C_{10}H_{14}$	1074-43-7
1.7	0.3	Acetyl valeryl	$C_7H_{12}O_2$	96-04-8
H/C	**N/C**	**Compound name**	**Formula**	
1.7	0.3	Butanenitrile	C_4H_7N	109-74-0
1.8	0.3	Cyanic acid, propyl ester	C_4H_7NO	1768-36-1
1.7	0.3	2,3-Diazabicyclo[2.2.1]hept-2-ene, 1,4-dimethyl-	$C_7H_{12}N_2$	71312-54-4
DBE	**C**	**Compound name**	**Formula**	
10	14	Phenanthrene	$C_{14}H_{10}$	85-01-8
7	14	1,4,5,8-Tetramethylnaphthalene	$C_{14}H_{16}$	2717-39-7
7	11	Naphthalene, 2-methyl-	$C_{11}H_{10}$	91-57-6
4	10	Benzene, 1-methyl-3-propyl-	$C_{10}H_{14}$	1074-43-7
5	10	Ethanone, 1-(2,4-dimethylphenyl)-	$C_{10}H_{12}O$	89-74-7
2	4	Butanenitrile	C_4H_7N	109-74-0
3	6	2-methoxyfuran	$C_5H_6O_2$	25414-22-6
4	6	Benzene	C_6H_6	71-43-2
4	9	Benzene, propyl-	C_9H_{12}	103-65-1
2	7	3-methylcyclohexene	C_7H_{12}	591-48-0

PW from oil production in Wyoming, which ranged from DBE 0-16 and C 6-25 with increased abundance from DBE 2-4 and C 10-15 (Wang et al., 2012).

Higher DBE values indicate greater aromaticity and less hydrogen saturation. Cho et al. determined that DBE values for shale-oil ranged between 4 and 7 as determined using FT-ICR-MS, and they found that shale-oil had a lower range of DBE relative to oil (Cho et al., 2013). DBE plots ranged from DBE 10-20 with C 25-50 for oil and ranged from DBE 5-25 with C 10-60 for gas-oil cuts (Stanford et al., 2007; Avila et al., 2012). The results for PW from shale-oil in the Permian Basin had dominant organic compounds with DBE values ranging from 2 to 8 (Fig. 7), which is comparable to the range for shale-oil (Cho et al., 2013). These results also support the observation that source-oil composition has a significant impact on PW composition. However, they also suggest solubility controls constrain PW composition. For example, low-solubility asphaltenes are typical constituents of petroleum that have DBE values generally higher (20–35) than byproducts of petroleum such as PWs (Wang et al., 2012). As noted for the van Krevelen evaluation, 3D DBE versus carbon number fingerprinting (another petroleomics evaluation) can also be used to characterize PW from oil and gas production including shale-oil. Both 3D van Krevelen and DBE plots provide additional mixture characterization information, and used together these provide a fingerprinting framework for high-resolution MS analysis results.

4. Conclusions

This study characterized the volatile organic compositional variability of late stage shale-oil PW from the Permian Basin. Benzene, and other BTEX compounds, are of significant concern for risk to human health and environment, and these compounds are elevated above drinking water and irrigation water quality standards. For beneficial use of the water, the organic contaminants must be removed from PWs (Xu et al., 2008a; Graham et al., 2015). Although not the focus of this work, several metals and anions had concentration ranges that exceeded drinking water or irrigation standards (i.e., B, Ba, Be, Ca, Cd, Cu, Fe, K, Li, Mg, Mn, Se, and Cl) (data not shown). However, for shale-oil PW the extremely elevated TDS represents the primary challenge for water treatment and reuse. The results presented herein suggest that partial treatment by removing suspended solids and organic contaminants would support some beneficial uses such as onsite reuse (e.g., hydraulic fracturing), bio-energy production, and mining (Xu et al., 2008a; Graham et al., 2015). Since potable water is still widely used for hydraulic fracturing, replacing potable water with partially-treated PW for hydraulic fracturing operations is one industrial reuse option that may be viable, and this would support water resource sustainability especially in water scarce arid regions such as the Permian Basin. However, minimization of compositional variability may be required for fracturing operations.

The compositional variability of volatile organics in shale-oil PW of the Permian Basin was evaluated through high-resolution molecular characterization using GC-ToF-MS and petroleomics evaluation techniques. As a lower-cost alternative to FT-ICR-MS, GC-ToF-MS provided high-resolution identification for the semivolatile and volatile compounds, which may be the greatest concern for PW and potentially associated environmental impacts. Approximately 1400 organic chemicals were observed with 300–400 identifiable structures, which fills a data gap for shale-oil PW. Shale-oil PW was found to be an extremely complex organic mixture for natural waters such that high-resolution MS was required to quantify the variability. The results suggest that the volatile organic compositional complexity may be used to fingerprint PW for forensic evaluations. However, this study was limited, and further evaluation is needed for different formations and types of PW. van Krevelen and DBE versus carbon number diagrams were used to evaluate composition patterns and variability, and used together these provide a fingerprinting framework for high-resolution MS analysis results. Such evaluation supports examination of potential environmental impacts for PW spills, beneficial use, or reuse alternatives. Treatment design also may be supported by high-resolution compositional analysis. Both shale-oil PWs and shale-oil have elevated alkanes compared to cyclohexane, cyclopentane, and naphthalene, and both are also dominated by N_1, N_2, N_1O_1, and O_2 containing heteroatomic compound classes, which confirms source oil control over shale-oil PW composition. Additionally, solubility and inorganic composition tends to impact dissolution

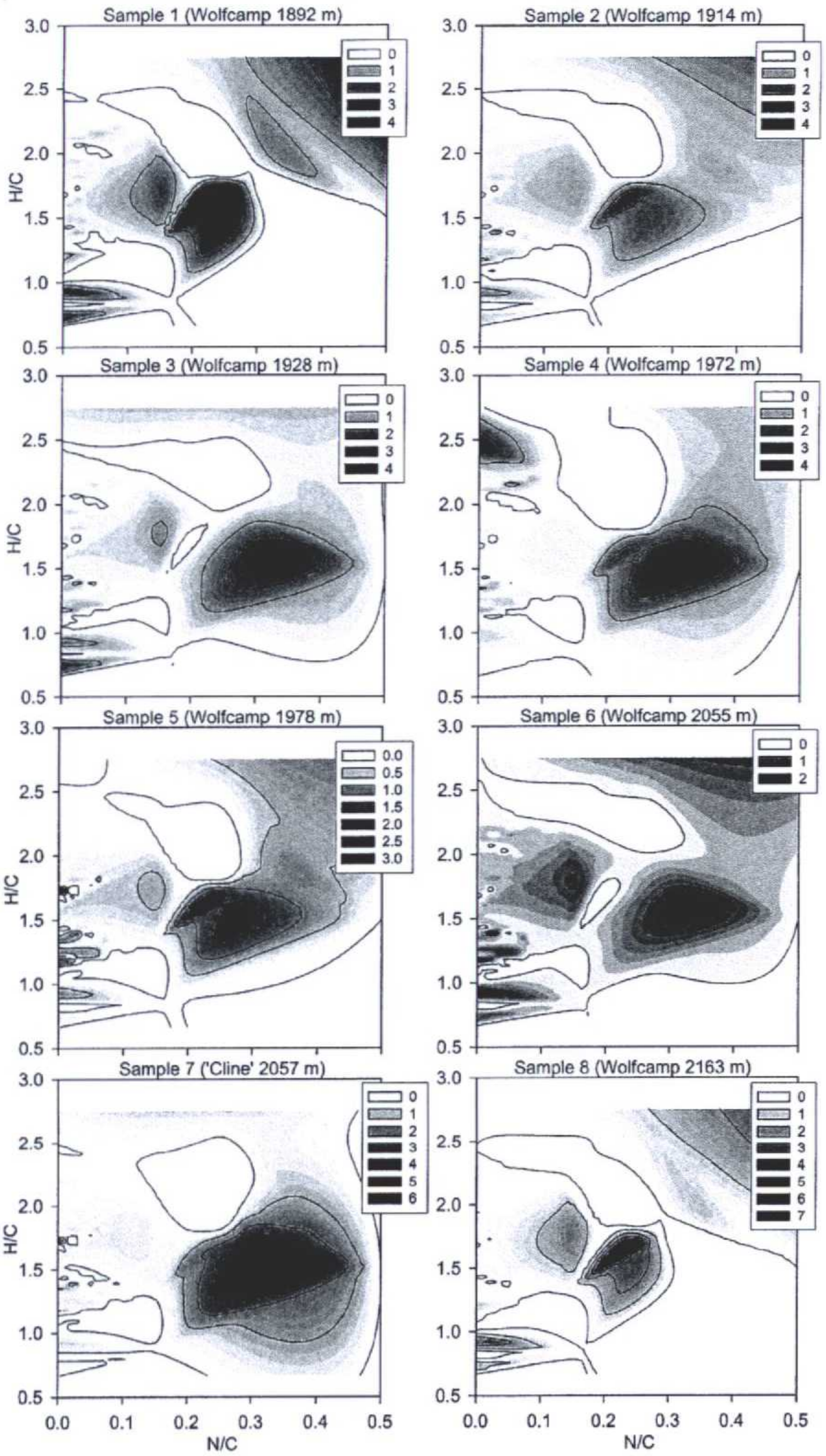


Fig. 6. Comparison of 3D van Krevelen (H/C versus N/C) with relative abundance (%) contours. Plots increase in sampled formation depth from left to right and top to bottom.

from shale-oil into PW. Moreover, molecular techniques have been shown to contribute tremendous information for characterization of complex organic mixtures such as PW, and high-resolution molecular characterization can be used to support evaluation of

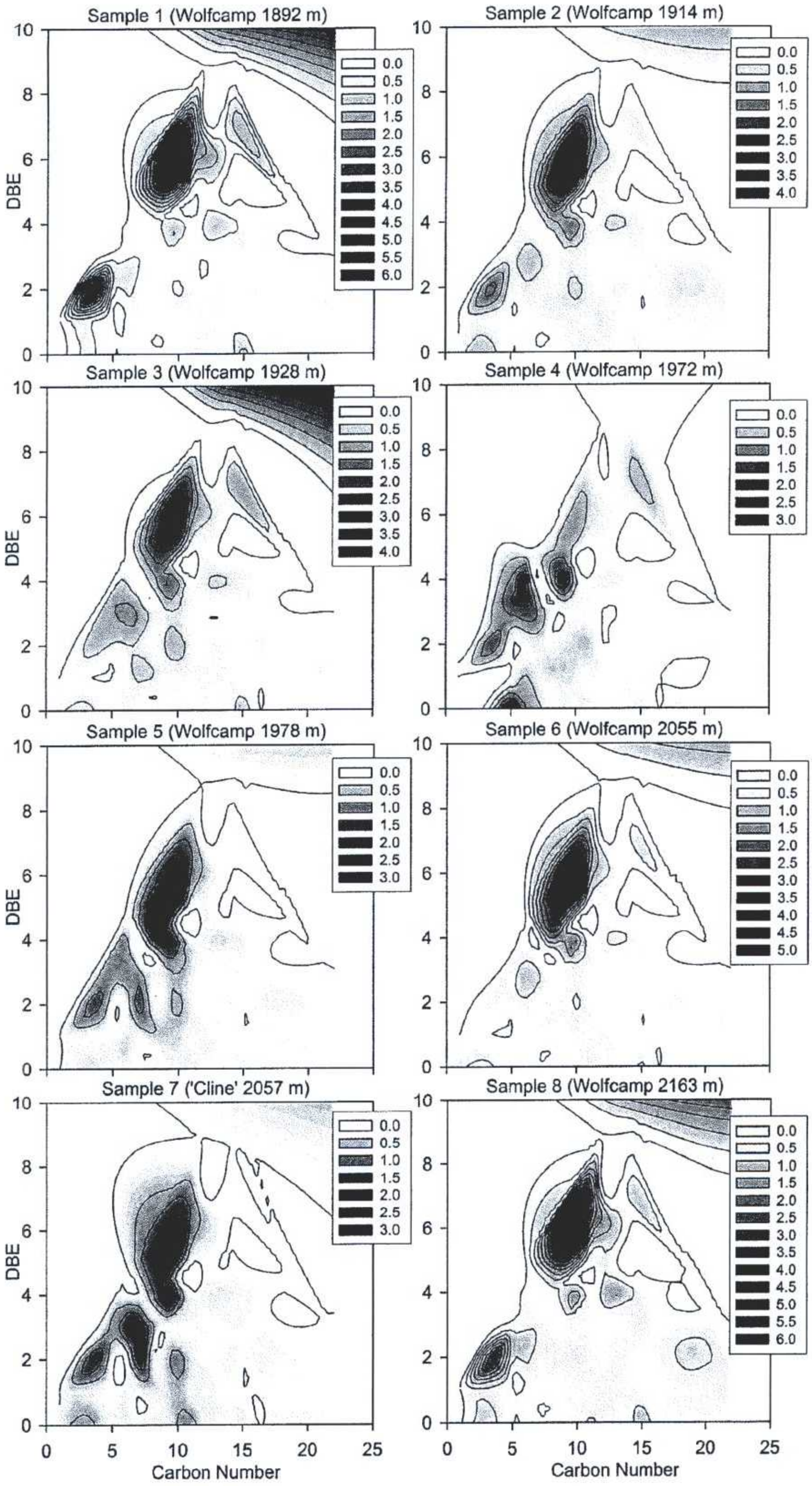


Fig. 7. Comparison of 3D double bond equivalence (DBE) versus carbon with relative abundance (%) contours. Plots increase in depth from left to right and top to bottom.

beneficial use options and treatment needs of PW.

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U.S. Department of the Interior
Fish & Wildlife Service
Environmental Contaminants Program

HYDROGEN SULFIDE MONITORING NEAR OIL AND GAS PRODUCTION FACILITIES IN SOUTHEASTERN NEW MEXICO AND POTENTIAL EFFECTS OF HYDROGEN SULFIDE TO MIGRATORY BIRDS AND OTHER WILDLIFE

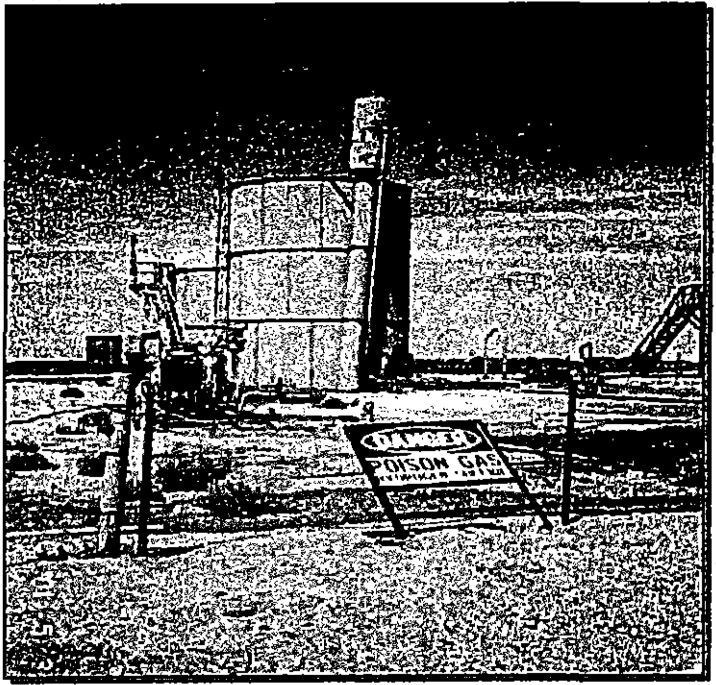

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EXHIBIT
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Hydrogen Sulfide Monitoring near Oil and Gas Production Facilities in Southeastern New Mexico and Potential Effects of Hydrogen Sulfide to Migratory Birds and Other Wildlife

by

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ABSTRACT

Hydrogen sulfide (H_2S) is a colorless, flammable and highly toxic gas with a characteristic odor of rotten eggs. It is produced naturally and as a result of human activity. Nationally, the largest source of hydrogen sulfide is from petroleum production. We monitored hydrogen sulfide near oil and gas production facilities near the cities of Roswell, Artesia, Hobbs, and Carlsbad in southeastern New Mexico and evaluated its potential effects on migratory birds and other species of wildlife. We deployed hydrogen sulfide monitors in different wildlife habitats near oil and gas production facilities starting November 6, 2002 and concluding August 6, 2003. Concentrations of hydrogen sulfide as high as 33 parts per million (ppm) were measured near the town of Loco Hills, New Mexico, approximately 25 miles (mi) (40 kilometers [km]) east of Artesia, New Mexico.

Point count surveys of migratory birds were also conducted to determine differences in habitat use of areas impacted by oil and gas production activities. Point count survey results of migratory birds from undisturbed sites (areas without oil and gas activities within 250 meters) were compared with disturbed sites (areas affected by oil and gas activities). Point count surveys began on November 21, 2002 and concluded on August 6, 2003. We found statistically significant differences in the average number of avian individuals per point count, the average number of avian species per point count, the species diversity, and the average concentration of hydrogen sulfide per point count at disturbed and undisturbed sites. Avian diversity and number of species as determined by point count surveys were significantly lower at disturbed sites than at undisturbed sites.

There is little information on the effect of hydrogen sulfide on migratory birds or other wildlife species even though they often occupy habitats that contain elevated hydrogen sulfide in the ambient air. In order to evaluate the toxicity of hydrogen sulfide to a variety of species, we modeled the dose and potential response of the sand dune lizard, as well as several migratory birds and mammal species to hydrogen sulfide. We determined that concentrations as low as 1 ppm may affect highly active migratory birds and mammals. Adoption of ambient hydrogen sulfide air quality standards as low as 1 ppm may be appropriate to protect wildlife.

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INTRODUCTION

Petroleum is a thick, flammable mixture of gaseous, liquid, and solid hydrocarbons that occurs naturally beneath the earth's surface. During extraction, petroleum is brought to the surface and transported to refineries where it is separated into liquid and gas fractions including natural gas, gasoline, kerosene, lubricating oils, paraffin wax, and asphalt (U.S. Environmental Protection Agency [USEPA] 1999). Hydrogen sulfide is found naturally in underground petroleum reserves. Hydrogen sulfide may be emitted or released during exploration, development, extraction, treatment and storage, transportation and refining of petroleum products (USEPA 1993).

In New Mexico, Dubyk *et al.* (2002), monitored ambient hydrogen sulfide levels and reported the highest concentrations (0 to 15 ppm) around oil and gas facilities near the Black River northeast of Whites City, New Mexico. In this region, Sias and Snell (1998) also had reported moribund wildlife species (e.g., owls and other raptors) as well as carapace remains of turtles near oil and gas wells that were known to emit hydrogen sulfide and other gases. Sias and Snell (1998) suggested that since some reptiles were strongly associated with the bottoms of dune valleys in the area, then these reptiles may be more susceptible to gas poisoning since hydrogen sulfide is heavier than air. The U.S. Fish and Wildlife Service (Service) was requested to review the available information to determine the risks posed to wildlife from local hydrogen sulfide emissions.

There are no Federal or State rules that identify protective air quality standards specifically to protect wildlife. There is little information on the effect of hydrogen sulfide on migratory birds or other wildlife species even though they often occupy habitats that contain elevated hydrogen sulfide in the ambient air. The Service therefore initiated this investigation (in conjunction with the New Mexico Department of Game and Fish and the U.S. Bureau of Land Management [BLM]) in order to determine: 1) the ambient concentrations in areas associated with oil and gas activities as well as in areas without that activity; 2) determine and associate the density, diversity or composition of the avian community in these two types of areas; 3) empirically test hydrogen sulfide toxicity to animals in a laboratory setting; and 4) identify whether measured hydrogen sulfide concentrations pose a risk to wildlife and which guilds of animals may be sensitive to hydrogen sulfide exposures in southeastern New Mexico. Note that Objective 3; the laboratory toxicity testing was not conducted due to lack of funding.

Hydrogen Sulfide Characteristics

Hydrogen sulfide (Chemical Abstract Service Registration Number 7783-06-4) is a colorless, flammable and highly toxic gas with a characteristic odor of rotten eggs. It is produced naturally and as a result of human activity (USEPA 1993). Natural sources include anaerobic bacterial reduction of sulfates and sulfur-containing organic compounds. Organic matter almost always contains sulfur and wherever it undergoes putrefaction (such as at the bottom of a lake, deep underground, in piles of manure, during decomposition, etc.), some of that sulfur is converted to hydrogen sulfide. Hydrogen sulfide is also found in crude petroleum, natural gas, volcanic gases, stagnant, thermal or polluted waters, livestock manure, coal pits and in springs (USEPA 1993).

Hydrogen sulfide is soluble in both water and oil and as a result can move great distances before conditions favor its emergence as a vapor. Hydrogen sulfide may evaporate from surface water, depending on temperature and pH. Because hydrogen sulfide vapor is heavier than air, it may also creep along the ground for a distance before being neutralized by chemical reactions, ignited, and it may pool in low-lying areas in the environment (USEPA 1993).

During petroleum extraction activities, impurities like hydrogen sulfide, water, sand, silt, or additives used to enhance extraction, are removed or allowed to volatilize into the air. In addition to hydrogen sulfide emission during petroleum production and refining, accidental air releases of hydrogen sulfide can occur through leaking tubing, valves, tanks, pipeline ruptures or open pits (USEPA 1993). During spills or leaks, hydrogen sulfide gas can volatilize to the atmosphere before clean up. Releases to the environment are primarily by emissions into ambient air, where the hydrogen sulfide is likely to remain for less than 1 day, but may persist for as long as 42 days in cold climates (Agency for Toxic Substances and Disease Registry [ATSDR] 2004). The concentrations of hydrogen sulfide in air in unpolluted areas are low (ATSDR 2004), with areas that have natural sources ranging between 0.1 and 0.3 parts per billion (ppb). Hydrogen sulfide is unlikely to bioconcentrate or biomagnify in the food chain, and has not been found to cause cancer (ATSDR 2004).

Hydrogen sulfide is corrosive; therefore, it is desirable to remove hydrogen sulfide during the petroleum conditioning process and during wastewater treatment (USEPA 1991). Hydrogen sulfide emission can occur during petroleum production and refining, through pipeline ruptures or leaking tubing, valves, flanges, tanks, and open pits (USEPA 1993). When natural gas is produced from the well that is not sold or used on-site, it can be flared or vented, thereby releasing carbon monoxide, nitrogen oxides, hydrogen sulfide, or sulfur dioxide to the atmosphere.

Rules and Regulations Governing Hydrogen Sulfide Emissions in New Mexico

The Clean Air Act requires the USEPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. Toxic air pollutants are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The USEPA regulates emissions of toxic air pollutants from industrial sources referred to as "source categories." Hydrogen sulfide was originally listed as a toxic air pollutant for which the USEPA was to assess the hazards to public health and the environment resulting from the emission of hydrogen sulfide associated with the extraction of oil and natural gas (USEPA 1993). However, it was later noted that a clerical error led to the inadvertent inclusion of hydrogen sulfide on the list of toxic air pollutants and it was removed (USEPA 1993). There are no national standards regulating hydrogen sulfide.

The New Mexico Environment Department (NMED) Air Quality Bureau has adopted 0.010 ppm as the ambient air quality standard for hydrogen sulfide (NMED 2002). However, Part 20.2.3.110.B(2) of the New Mexico Annotated Code (NMAC) identifies a regional air quality standard for hydrogen sulfide in the Pecos-Permian Basin (30-minute [min] average) as 0.100 ppm. The Pecos-Permian Basin Intrastate Air Quality Control Region is composed of Quay, Curry, De Baca, Roosevelt, Chaves, Lea, and Eddy Counties in New Mexico. Also, the ambient air quality standard for hydrogen sulfide is 0.03 ppm (30-min average) within corporate limits of municipalities in the Pecos-Permian Basin Intrastate Air Quality Control Region or within 5 mi (8 km) of the corporate limits of municipalities having a population of greater than twenty thousand. However, there are no requirements for monitoring hydrogen sulfide emissions from any new source or from the net increase of hydrogen sulfide emissions where these emissions could cause ambient concentrations to exceed the air quality standards in New Mexico unless those emissions exceed 10 tons of sulfur per year from a stationary source (20.2.74.502 NMAC).

The New Mexico Oil Conservation Division of the Energy, Minerals, and Natural Resources Department (EMNRD) has promulgated rules regarding the emission of hydrogen sulfide from any well or gas-producing facility in New Mexico (EMNRD 2001). These rules provide for the protection of the public's safety in areas where hydrogen sulfide concentrations are greater than 100 ppm. Generally, any gas-processing facility where hydrogen sulfide is present at concentrations of 100 ppm or more must take reasonable measures to forewarn and safeguard people that have occasion to be on or near the area. Wells drilled where there is substantial probability of people encountering hydrogen sulfide gas in concentrations of 500 ppm or more must have warning "poison gas" signs. Facilities (except gas-processing plants) having storage tanks with hydrogen sulfide gas in concentrations of 1,000 ppm or more must have identifying signs indicating the specific protective measures that may be necessary to protect public safety. Any well, lease, or processing plant handling gas with a hydrogen sulfide concentration and volume that equates to 10,000 cubic feet (ft^3) (283 cubic meters [m^3]) per day or more, which is located within 0.25 mi (0.4 km) of a dwelling, public place, or highway, must install safety devices and maintain them in operable conditions or establish safety procedures designed to prevent the undetected escape of hydrogen sulfide as well as prepare a contingency plan for people's safe evacuation.

The BLM has applied rules and regulations for well leases and facilities on all BLM lands in New Mexico (43 Code of Federal Regulations [CFR] 3160; see BLM 1991). The BLM has identified areas or zones they manage for oil and gas production (along with other resource uses and goals), where postings must occur and human entry must be accompanied by monitoring devices to reduce the risk of hydrogen sulfide exposure (BLM 1997). The BLM has also identified, mapped, and posted signs in areas where elevated hydrogen sulfide releases from oil and gas wells are known to occur that may pose risks to human health and safety in New Mexico (BLM 1997).

Most gas emissions are minimized through prevention (i.e., preventive maintenance and occasional monitoring, inspections, leak detection and notification systems, installation of catalytic converters, filters, sponges, routine replacement of gaskets, seals, valves, tightening connections, and welding, as well as educating and informing the workforce)(USEPA 1993). Flaring or burning off gases may sometimes be used to reduce air emissions that are unavoidable. Nearly all oil and gas production wells are equipped with a vent or flare to release unusual pressure, and some wells that produce only a small amount of natural gas will vent or flare it when there is no on-site use for the gas (e.g., to power engines), no pipeline nearby to transport the gas to market, and no regulations regarding its disposal (USEPA 1993). Since natural gas has economic value, flaring is usually considered a last resort. When a gas is flared, it passes through the vent away from the well, and is burned in the presence of a pilot light. Although it is preferable to prevent the emission in the first place, flaring has benefits over simple venting of unburned material. However, the practice of flaring also produces sulfur dioxide, which is a regulated air pollutant (USEPA 1993).

Toxicity of Hydrogen Sulfide to Wildlife

There are no Federal or State rules that identify protective air quality standards for wildlife. Few studies address the risks posed to wildlife from hydrogen sulfide emissions. One investigation by Siegel *et al.* (1986) examined the ambient levels of hydrogen sulfide at Sulphur Bay Wildlife Area in New Zealand where shorebirds were exposed to hydrogen sulfide of geothermal origin at concentrations of 0.13 to 3.9 ppm. They found fewer species of birds used this habitat compared to similar wetlands without detectable levels of hydrogen sulfide. However, no parameters of exposure were measured at either the population level or the individual level. The Canadian Wildlife Service also conducted a study of the effects of a gas well blowout in Alberta, Canada on wildlife (New Norway Scientific Committee 1974). Concentrations between 5 and 10 ppm were documented and birds and small animals were absent from the study area after the blowout. The New Norway Scientific Committee (1974) suggested that low concentrations of hydrogen sulfide, as low as 5 to 10 ppm, negatively affect habitat usage by avian species.

Data on the effects of hydrogen sulfide are only well documented for common test animals and humans (ATDSR 2004). The following information on human toxicity was included because the mechanism of hydrogen sulfide toxicity is considered to be common among all vertebrates that utilize aerobic pathways of metabolism (USEPA 2003; U.S. National Library of Medicine [USNLM] 2003). The characteristics of acute hydrogen sulfide toxicity are dependent on the concentration and duration of exposure. Exposure is usually by inhalation. At high concentrations (250-500 ppm), hydrogen sulfide acts as a respiratory irritant, which can lead to a pulmonary edema (USEPA 2003; USNLM 2003). At higher concentrations (500-1,000 ppm), hydrogen sulfide acts as a systemic poison, causing unconsciousness and death by respiratory paralysis in minutes (USNLM 2003). Long-term damage and death in small mammals occurs when hydrogen sulfide gas levels exceed 50-100 parts per million (ppm) (Dahme *et al.* 1983). A single 4-hour exposure to hydrogen sulfide concentrations of 15-100 ppm may cause eye irritation and conjunctivitis ("gas eye"), convulsions and pulmonary edema in rodents (Lopez *et al.* 1989). At concentrations ranging from 10 to 25 ppm people report flu-like symptoms including headaches, dizziness, nausea, vomiting, irritation of the eyes, nose and throat, fatigue, insomnia, and digestive disturbances (National Institute for Occupational Safety and Health [NIOSH] 1977). The health effects of chronic, low-level exposure to hydrogen sulfide to wildlife or humans, however, are not well defined (USEPA 2003; ATSDR 2004).

After inhalation, hydrogen sulfide enters the circulation directly across the alveolar-capillary membrane where it dissociates into a sulfide ion (USNLM 2003). The sulfide ion is then selectively taken up by the brainstem where it interferes with neurotransmitter levels and also reversibly interacts with a number of enzymes, proteins, including hemoglobin and myoglobin. Sulfide ions will bind to cytochrome-oxidase within mitochondria, thereby blocking electron transport leading to metabolic acidosis to cytotoxic anoxia, and finally, cell death (Smith 1991). As a cellular poison, the effects of hydrogen sulfide are seen across all organ systems and would be expected to behave similarly in all vertebrate species that utilize aerobic metabolism such as in migratory birds, mammals, certain reptiles and amphibians (Dombkowski *et al.* 2005).

Hydrogen sulfide has been recently identified as vasoactive (*i.e.*, affecting the blood vessels) in all vertebrate classes of mammals, birds, reptiles and fish (Dombkowski *et al.* 2005). When isolated blood vessels were exposed to hydrogen sulfide vasoactivity was observed including constriction, dilation, and multiphasic responses that were both species- and vessel-specific (Dombkowski *et al.* 2005). The ability of hydrogen sulfide to serve as either (or both) a vasoconstrictor or vasodilator is an evolutionary feature for regulation of vasoactivity that seems to have been exploited by nearly all vertebrates (Dombkowski *et al.* 2005). As a result, hydrogen sulfide may trigger a "startle" response in exposed wildlife by constricting blood vessels, increasing heart rate and blood pressure with a consequent increase in respiration and glucocorticoid release (Gabrielsen and Smith 1995, Maren 1999).

Olfactory Toxicity

The olfactory toxicity of hydrogen sulfide exposure deserves special emphasis for wildlife because their chemical senses such as odor detection are well-developed to detect food, danger, or potential mates (Geist 2000; Rehorek *et al.* 2000; Getchell and Getchell 2005; Lledo *et al.* 2005). In most terrestrial vertebrates, the vomeronasal organ is a dome-shaped, cartilage-encased nasal chemosensory structure found on the rostral floor in the nasal cavity (Rehorek *et al.* 2000). The vomeronasal organ is an important interface between the environment and the central nervous system (Rehorek *et al.* 2000). Sensory perception is a process by which information from the external world is subsequently reformatted into an internal state, so this organ is responsible for correctly coding sensory information from thousands of odorous chemicals and other stimuli to the brain (Lledo *et al.* 2005). Snakes are thought to possess the most complex vomeronasal organs. Odorous compounds, even when present at concentrations that cannot be consciously detected by people, often produce a distinct response in a variety of animals (Roth and Goodwin 2002).

For land animals, the initial step in olfactory response involves the interaction of an odor, usually a volatile organic molecule, with specific receptors located on the surface of the olfactory sensory neurons that penetrate the skull and terminate in the olfactory bulb at the base of the brain (Roth and Goodwin 2002). After entering, odorants dissolve in the mucous lining, bind to specific receptors on the neuron's cilia, which opens various ion channels and depolarizing the membranes of sensory neurons sending various signals throughout the brain (Mombaerts 1999). There are substantial animal toxicology data demonstrating damage to the olfactory senses by airborne chemicals (Cowart *et al.* 1997), and particularly due to hydrogen sulfide exposure (USEPA 2003; ATSDR 2004).

In the derivation of the reference concentration (RfC) used for the Integrated Risk Information System, the USEPA (2003) used the results of a study by Brenneman *et al.* (2000) that exposed 10-week old male rats to 0, 10, 30, or 80 ppm hydrogen sulfide for 6 hours per day for 10 weeks. At the end of the exposure period, the noses of the animals were dissected, sectioned and histological evaluations were made of the respiratory and olfactory epithelium. Lesions were observed in the olfactory mucosa in the animals exposed to 30 or 80 ppm hydrogen sulfide (Brenneman *et al.* 2000). The critical effects in the Brenneman *et al.* (2000) study were nasal lesions of the olfactory mucosa; with 30 ppm identified as the Lowest-Observable-Adverse-Effect Level (LOAEL), 10 ppm identified as the No-Observable-Adverse-Effects-Level (NOAEL), 100 ppm identified as the Frank-Effects Level (FEL) by the USEPA (2003) in their derivation of the RfC. Lopez *et al.* (1987) and Moulin *et al.* (2002) identified that the olfactory epithelium was more sensitive to the toxic effects of hydrogen sulfide than the respiratory epithelium. Credence for the hypothesis that hydrogen sulfide specifically impacts the olfactory senses is supported by the correlation between hydrogen sulfide flux and the human nasal response to hydrogen sulfide odor (USEPA 2003).

In humans, the odor threshold begins at 0.003-0.3 ppm, is easily perceptible at 1 ppm, and is reminiscent of rotten eggs at 3-30 ppm (ATSDR 2004). A sickeningly sweet odor is described from 30-100 ppm above which rapid olfactory fatigue and paralysis ends perception (ATSDR 2004). Prolonged exposure to low concentrations may also result in olfactory paralysis or nasal membrane necrosis (USNLM 2003). Compared with animals, humans have a relatively small area of olfactory epithelium (USEPA 2003).

Reptiles, birds and mammals posses one or more pairs of cartilaginous, epithelially covered projections within the nasal cavity know as turbinates (Geist 2000). In reptiles, these turbinates are relatively simple structures associated with olfaction, however, with birds and mammals, these turbinates are relatively elaborate convoluted structures lined with moist mucociliated epithelium (Geist 2000). Respiratory turbinates are situated directly in the path of respiratory airflow. As inspired air passes through the nasal cavities and over the moist surfaces of the respiratory turbinates, heat and water are exchanged – as is hydrogen sulfide (Geist 2000).

After passing through the nasal passages, inspired air passes down the trachea and through to the main respiratory organ of mammals, birds and reptiles. The trachea consists of repeatedly branching longitudinal and transverse tubes and ducts that terminate in numerous blind-ending sacs or alveoli in the lungs of terrestrial animals. The respiratory organs of mammals, birds, and reptiles are very different from each other (Bennett 1973; Brown *et al.* 1997). However, these structural differences and the differences in ventilation rates for these different classes of animals (mammals, birds and reptiles) can be used to account for the relative inhalation dose of hydrogen sulfide and therefore, the derivation of an inhalation reference concentration for animals (USEPA 1994).

STUDY AREA

The study area includes portions of Chaves, Eddy, and Lea Counties in southeastern New Mexico (Figure 1). Generally, the study area includes the areas known as the Southern High Plains, the lower Pecos River drainage basin, the Caprock, and the Mescalero Sands (also known as the Shinnery Sands Ecoregion). The Mescalero Sands are an extensive deep-sand dune area west of the Caprock, south of State Highway 70, north of State Highway 31, and east of the Pecos River (Griffith *et al.* 2006). Portions of the Mescalero Sands have been designated as a National Natural Landmark, an Outstanding Natural Area, and a Research Natural Area (BLM 1997). Hawley (1986) identified this area as part of the Great Plains Province, while Dick-Peddie (1993) further identified this area as Plains-Mesa Sand Scrub due to the presence of shin oak (*Quercus havardii*). This region also contains extensive petroleum resources of the Permian Basin that annually produce over 65 million barrels (7.5 million m^3) of crude oil and over 550 trillion ft^3 (15.6 trillion m^3) of natural gas (EMNRD 2000). Irrigated farming occurs along the Pecos River in lower Chaves and Eddy Counties.

Associated with the Mescalero Sands is a community of plants and animals called a "sand shinnery" (Peterson and Boyd 1998). Shin oaks co-dominate the sand shinnery vegetative community along with sand sagebrush (*Artemisia filifolia*), tall grasses and forbs. These shin oaks comprise the largest stand of oaks in the United States and occupy nearly six million acres in northern Texas, western Oklahoma, and southeast New Mexico. This shin oak forest is only 1 to 4 ft (0.3 to 1.2 m) tall and is composed of ancient plants, most of them hundreds to thousands of years old (Peterson and Boyd 1998). Two wildlife species characteristic of the sand shinnery include the lesser prairie-chicken (*Tympanuchus pallidicinctus)*, known for its courtship rituals, and the sand dune lizard (*Sceloporus arenicolus*). Both of these species are candidates for listing under the Endangered Species Act as their population declines have been attributed to habitat loss and degradation (Taylor 1980; Service 1998; Painter *et al.* 1999). Common avian species in the study area such as mourning dove, scaled quail, red-tailed hawk, and common roadrunner were described by Peterson and Boyd (1998). Table 1 lists these wildlife species and others found in the area along with their scientific names.

METHODS

Monitoring Site Selection and Characterization

Areas that were selected for monitoring or for bird surveys were characterized as "disturbed" if they were within ~80 to 100 ft (25 to 30 meters [m]) of any visible well pads, drilling rigs, oil storage tanks, pipelines or oil pumps. Often there was a distinct change in the vegetative community near the well pads, tanks, pipelines or pumps as the vegetation was cleared, or was distinctly different from the surrounding area. Areas were characterized as "undisturbed" if they were at least 800 to 1000 ft (~250 to 300 m) from any visible well pads, storage tanks, pipelines or processing facilities and the vegetation community appeared homogenous in all directions (except for roads – see below).

We employed a survey technique recommended by Ralph (1993) that included the systematic placement bird survey point counts at designated distances along roads or trails rather than random sampling design. Site selection for surveys and handheld hydrogen sulfide monitoring was conducted by access along tertiary roads (*i.e.*, often unpaved County roads). A systematic grid of points along tertiary roads was implemented. A randomization program was used to choose those tertiary roads among those available. Thereafter the distance between survey locations was set at approximately every 0.6 mi (~1,000 m) as gauged by an odometer or as measured using a global positioning system (GPS; Garmin, Model GPS V, Olathe, Kansas. The GPS was Wide Area Augmentation System-enabled, set to degrees, minutes and seconds using the 1983 North American Datum). This GPS was also used to mark the location of all observations. The process of driving along roads and stopping approximately every 0.6 mi (1,000 m) was repeated until at least eight bird surveys with eight hydrogen sulfide measurements with a handheld hydrogen sulfide gas detector were conducted each from disturbed and undisturbed sites.

Avian Survey Methods

Few studies have measured natural or accidental exposure of wildlife to hydrogen sulfide. Additionally, few studies have been conducted on bird communities in areas associated with the extensive oil and gas activities in southeast New Mexico. In this study, we quantified the concentrations of hydrogen sulfide in the environment using long-term stationary and hand-held monitors in conjunction with point count surveys of the avian community. A point count is a total of all the birds detected visually and aurally by an observer from a fixed station during a fixed period of time (Ralph *et al.* 1993, 1995; Hamel *et al.* 1996; Huff *et al.* 2000). We used point counts to determine the presence or absence of bird species and their number along with our characterization of the landscape as either "disturbed" or "undisturbed" by oil and gas activities. Note that we did not quantify the area's vegetation within the observational point count area (*i.e.*, vegetation species, number, or spatial extent).

Point count bird surveys were conducted along tertiary roads as described above. Point count surveys began on November 21, 2002 and concluded on August 6, 2003. Counts lasted 3 to 5 min and survey sites consisted of a circle with a radius of approximately 164 ft (50 m). Initial tests of the statistical differences in the point count results from either 3- or 5-min point count surveys of similar habitats showed no detectable difference (t-test, $P = 0.69$). Once the survey started, all birds that were seen or heard by a trained observer within the point count circle were recorded. The total number of birds, number of species, and number of individuals of each species were recorded. Using a handheld hydrogen sulfide monitor (Industrial Scientific, Model HS560, Oakdale, Pennsylvania), the average concentration of hydrogen sulfide was also recorded from measurements before, during and after the bird survey. Bird surveys were conducted during winter, spring and summer (but not in autumn), as migratory bird community composition changes with season, however, surveys were not repeated in the same areas during each season (winter, spring and summer).

To test for differences between hydrogen sulfide data and bird habitat use we conducted point count surveys of birds in areas that we classified as disturbed or undisturbed by oil and gas activities and season. For each season and for each habitat classification, the number of birds, the number of species, and the number of individuals of each species were summed. Then the average number of birds per point count, the average number of species per point count, the average number of individuals of each species per point count, and the average concentration of hydrogen sulfide gas per point count location were calculated. For each season, the differences in the average number of birds per point count, the average number of species per point count, and the average concentration of hydrogen sulfide gas at the disturbed sites and the undisturbed sites were determined with the use of t-tests (Schefler 1969). For each season and the study overall, differences between the average numbers of individuals of each species per point count for each habitat type were determined with the use of an rXc contingency table (Schefler 1969). The statistical threshold of acceptability that was used was $P \leq 0.05$ (Schefler 1969).

Long-term Hydrogen Sulfide Monitoring Methods

Site selection for hand-held hydrogen sulfide monitoring was as described above. However, three sites were preselected for long-term monitoring based on site characteristics. Long-term monitoring occurred northwest of Carlsbad, New Mexico, due to concerns reported by the community for hydrogen sulfide odors; west of Tatum, New Mexico, as the reference condition; and near Maljamar, New Mexico. For the long-term monitoring of hydrogen sulfide, an Odalog H_2S Gas Logger (App-Tek International Proprietary Limited, Munich, Germany) was attached to a nearby shrub at approximately 3 ft (~1 m) in height using a chain and lock. The monitors were placed as close as possible (less than 50 ft [15 m]) to oil and gas equipment within disturbed sites and over 1,000 ft (300 m) away from any such equipment at the undisturbed site. The hydrogen sulfide monitors contained a data logger that recorded the hydrogen sulfide concentration to within 1 ppm once every minute. The monitors were cleaned and inspected every 2 to 4 weeks, data were downloaded onto a laptop computer and batteries changed prior to placement at a new site. Monitors were calibrated according to manufacturer's specifications and data were later downloaded and then imported into a spreadsheet for graphic representation. Data collection of long-term hydrogen sulfide monitoring began on November 6, 2002 and concluded on August 6, 2003.

Derivation of Wildlife Toxicity Benchmarks

One of the challenges of evaluating the potential effects on wildlife by ambient hydrogen *sulfide concentrations is that there is little or no direct exposure data on which to base the* thresholds of concern. The USEPA (1994) developed a methodology for estimation of the RfC as benchmark estimates of the quantitative dose response assessment of chronic toxicity for individual inhaled chemicals such as hydrogen sulfide. The USEPA (1994) RfC methodology accounts for the dynamics of the respiratory system to account for species-specific relationships of exposure concentrations to delivered doses. The RfC methodology, which is a set of procedures to estimate a dose-response assessment, has inherent uncertainty and imprecision because it requires judgment, the use of assumptions, and data extrapolations (USEPA 2003).

The RfC derivation begins with the identification of a NOAEL and a LOAEL, which are determined for a specified adverse effect from the exposure levels of a given individual study. The USEPA (2003) validated and used the results of the Benneman *et al.* (2000) study to derive the RfC for humans, and therefore we shall use the results of the Benneman *et al.* (2000) *study to derive a wildlife specific RfC for evaluation in this report.* The NOAEL and LOAEL may need to be converted to standard units (milligrams per cubic meter [mg/m^3]), normalized to an exposure time (24 hours [h]), and adjusted to a wildlife species equivalent dose *by accounting for species-specific dosimetric differences in the surface area of the* trachea region and the ventilation rate. The dosimetric adjustment factors wildlife species were calculated as:

$$\text{NOAEL}_{\text{wildlife}}\ (\text{mg/m}^3) = \text{NOAEL}_{\text{rat}}\ (\text{mg/m}^3) \times \text{DAF}_r \qquad \text{(Equation 1)}$$

where:

$\text{NOAEL}_{\text{wildlife}}$ is the NOAEL (or analogous effect level) for a particular wildlife species obtained using USEPA (1994).

$\text{NOAEL}_{\text{rat}}$ is the NOAEL (or analogous effect level) from the Benneman *et al.* (2000) study.

DAF_r *is a dosimetric adjustment factor for the surface area of the trachea and either* the resting respiration rate or the active respiration rate for each species.

Therefore, the DAF_r for any wildlife species compared to the laboratory rat would be:

$$\text{DAF}_r = \left(\frac{\left(\dfrac{\textit{Rat ventilation rate} \quad (ml/\min)}{\textit{surface area of trachea} \quad (\text{cm}^2)} \right)}{\left(\dfrac{\textit{Wildlife ventilation rate} \quad (ml/\min)}{\textit{surface area of trachea} \quad (\text{cm}^2)} \right)} \right) \qquad \text{(Equation 2)}$$

The ventilation rates and surface area of the laboratory rat were reported by the USEPA (1994). However, ventilation rates and trachea dimensions area in wildlife species are a function of body mass (Calder 1968; Hinds and Calder 1971; Bennett 1973; Brown *et al.* 1997; Frappell *et al.* 2001). We used the avian body masses reported by Dunning (1993) and Sell (1977) as well as the mammalian body masses reported and Silva and Downing (1995) to calculate the ventilation rates and trachea surface area while active or at rest (Table 2). However, while respiration rates for various reptile species was reported by Bennett (1973), and body mass was reported by Degenhardt *et al.* (1996), information on trachea surface area was not available. Therefore, we made an assumption that sand dune lizard trachea dimensions were equivalent to that of a bird of equal mass (0.005 kilograms [kg]). Then we used geometry to determine the surface area of the trachea. We assumed the trachea radius was one half the trachea width and the surface area was equal to that of a cylinder with a circumference of 2 times the trachea radius times pi ($2\pi r$) times the height that is equal to that of the trachea length (Table 2). Note that if hydrogen sulfide toxicity is not related to exposure by ventilation, but rather by species-specific differences in gas exchange surfaces, then this dose scaling may not be appropriate.

Calculation of a protective air quality standard for wildlife would require the development of an RfC using uncertainty factors to account for species differences, laboratory-to-field study modifiers, and duration of exposure. We compared the ambient concentrations of hydrogen sulfide to the NOAEL to indicate potential risks to wildlife. The lowest NOAEL concentration was rounded to an integer and that value was recommended as an interim ambient air quality recommendation to protect wildlife until an RfC could be further developed. These interim ambient air quality recommendations are therefore "action levels" as they do not consider a number of uncertainty factors normally used to derive ambient air quality criteria (USEPA 1994, 2003)

Determination of Potential Sources of Monitored Hydrogen Sulfide Concentrations

For those two events when hydrogen sulfide concentrations exceeded 5 ppm during our long-term monitoring, we evaluated the nearby wind speed and direction for the hour at which the elevated hydrogen sulfide concentration was measured to determine potential source(s). Wind data at the monitoring device was unavailable; therefore we obtained hourly wind speed and direction from a nearby weather station in Roswell, New Mexico (NOAA 2003) and assumed they were representative. For example, when wind speeds and direction were reported at 17 mi/h (~27 km/h) from the north, we assumed that the measured hydrogen sulfide concentrations came from sources in an upwind cone up to 17 mi (24 km) in length were the most likely sources of the hydrogen sulfide concentrations measured.

RESULTS

Long term hydrogen sulfide monitors were placed near seven oil well pumping jacks and eight oil tanks for periods averaging 2 to 4 weeks at a time. For most sites, the peak concentrations of hydrogen sulfide measured were often less than 6 ppm (Figures 2 through 17). The highest concentration (33 ppm) was measured near an oil tank (North 32 ° 49' 54" by West 104 ° 02' 41") for a period lasting about an hour. A concentration of 27 ppm was also measured at an oil tank (North 32° 36' 48" by West 103 ° 18' 44") for a period of 2 h. (Figure 13). At these sites, during periods when hydrogen sulfide was elevated, the 1-hour average was also found to exceed the New Mexico air quality standard. The hydrogen sulfide monitors that were placed in reference habitats that were far removed from oil and gas production facilities had peak hydrogen sulfide concentrations less than 1 ppm.

During the winter survey season, a total of 52 point count surveys of birds were conducted on undisturbed sites and 50 point count surveys were conducted on disturbed sites. A total of 198 birds representing 34 species were counted on undisturbed sites and 40 birds representing 19 species were counted on disturbed sites (Table 3, Figure 18). The average number of individuals counted per point count survey at the undisturbed sites was 3.8 (Standard Deviation [S.D.] = 4.4). The average number of individuals counted per point count survey at the disturbed sites was 0.8 (S.D. = 1.3). The observed difference in the average number of individuals at the undisturbed and disturbed sites was statistically significant (t-test, P < 0.01). The average number of species counted per point count survey at the undisturbed sites was 1.3 (S.D. = 1.2) and 0.5 (S.D. = 0.7) at the disturbed sites. Also the difference in the average number of species counted per point count at the undisturbed and disturbed sites was statistically significant (t-test, P < 0.01). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, P < 0.01). The average concentration of hydrogen sulfide present at the undisturbed sites was 0.1 ppm (S.D. = 0.3) and at the disturbed sites was 1.5 (S.D. = 0.7). The observed difference was statistically significant (t-test, P < 0.01).

During the spring survey season a total of 42 point count surveys of birds were conducted on undisturbed sites and 33 point count surveys were conducted on disturbed sites. A total of 62 birds representing 15 species were counted on undisturbed sites and six birds representing four species were counted on disturbed sites (Table 4, Figure 19). The average number of individuals counted per point count survey at the undisturbed sites was 1.5 (S.D. = 1.4) and 0.2 (S.D. = 0.5) at the disturbed sites. The observed difference in the average number of individuals was statistically significant (t-test, P < 0.01). The average number of species counted per point count survey at the undisturbed sites was 0.9 (S.D. = 0.1) and 0.2 (S.D. = 0.1) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, P < 0.01). The average concentration of hydrogen sulfide at the undisturbed sites was 0.2 ppm (S.D. = 0.5) and 1.2 ppm (S.D. = 0.6) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01).

During the summer survey season a total of 26 point count surveys of birds were conducted on undisturbed sites and 33 point count surveys were conducted on disturbed sites. A total of

54 birds representing 15 species were counted on undisturbed sites and 15 birds representing five species were counted on disturbed sites (Table 5, Figure 20). The average number of individuals counted per point count survey at the undisturbed sites was 2.1 (S.D. = 2.3) and 0.5 (S.D. = 0.8) at the disturbed sites. The observed difference in the average number of individuals was statistically significant (t-test, P < 0.01). The average number of species counted per point count survey at the undisturbed sites was 0.9 (S.D. = 0.1) and 0.3 (S.D. = 0.5) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, P < 0.01). The average concentration of hydrogen sulfide at the undisturbed sites was 0.3 ppm (S.D. = 0.5) and 2.0 ppm (S.D. = 1.6) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01).

Overall, a total of 120 point count surveys of birds were conducted on undisturbed sites and 116 point count surveys were conducted on disturbed sites. A total of 314 birds representing 40 species were counted on undisturbed sites and 58 birds representing 25 species were counted on disturbed sites (Table 6, Figure 21). Lesser prairie-chickens were not observed at any of the study sites. The average number of individuals counted per point count survey at the undisturbed sites was 2.6 (S.D. = 3.3) and 0.5 (S.D. = 0.9) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01). The average number of species counted per point count survey at the undisturbed sites was 1.1 (S.D. = 0.9) and 0.4 (S.D. = 0.6) at the disturbed sites. The observed difference was statistically significant (t-test, P < 0.01). The observed differences in species composition at the undisturbed and disturbed sites were statistically significant (rXc contingency table, P = 0.04). The average concentration of hydrogen sulfide at the undisturbed sites was 0.2 ppm (S.D. = 0.4) and 1.6 ppm (S.D. = 1.1) at the disturbed sites. The difference was statistically significant (t-test, P < 0.01).

DISCUSSION

Dubyk *et al.* (2002), monitored ambient hydrogen sulfide levels in areas of New Mexico near these facilities: 1) a sewage treatment plant; 2) four dairy operations; 3) a poultry operation; 4) a liquid septage disposal facility; 5) a sewage sludge disposal facility; and, 6) nine oil and gas facilities. All of the facilities they inspected indicated a high likelihood that they could exceed the New Mexico air quality standards for hydrogen sulfide. At oil and gas facilities, hydrogen sulfide concentrations ranged from 0 to 15 ppm; the highest concentrations were reported near the Black River northeast of Whites City, New Mexico. Dubyk *et al.* (2002) reported that all other facilities were measured with ambient concentrations less than 0.11 ppm. Dubyk *et al.* (2002) also reported that background ambient air concentrations of hydrogen sulfide in New Mexico range from 0 to 0.010 ppm and averaged 0.0057 ppm.

We measured concentrations of hydrogen sulfide as high as 33 ppm near an oil tank in the vicinity of Loco Hills, New Mexico, approximately 25 mi (40 km) east of Artesia, New Mexico. Using wind speed and direction, oil production wells and injection wells were identified upwind of the elevated hydrogen sulfide concentrations detected by the long-term monitors (Figure 22). However, it is uncertain if any of these particular production or injection wells were the source of the measured hydrogen sulfide peak concentrations in the ambient air.

Based on our dosimetric calculations, mammals appeared to be more sensitive to hydrogen sulfide toxicity than either birds or reptiles. Reptile ventilation rates are slower and therefore reduce the amount of hydrogen sulfide exposure to their tissues. Hydrogen sulfide concentrations less than 2 ppm appear not to pose a risk to mammal species at rest, while concentrations greater than 5 ppm pose a risk to wildlife and are likely to affect their olfactory senses, irritate their eyes and mucus membranes, or dilate their blood vessels and cause a startle or stress reaction (Table 2). Mammals exposed to greater than 11 ppm would be more likely to flee an area or succumb to hydrogen sulfide toxicity (Table 2).

Avian species are more at risk when they are active or flying as they inhale deeper. Hydrogen sulfide concentrations less than 1 ppm would appear not to pose a risk to birds when they are active or flying (Table 2). Hydrogen sulfide concentrations less than 8 ppm appear not to pose a risk to avian species at rest, while concentrations greater than 25 ppm pose a risk to avian species and may affect their olfactory senses, irritate their eyes and mucus membranes, or dilate their blood vessels and cause a startle or stress reaction (Table 2). Based on these analyses, ambient air hydrogen sulfide concentrations should be less than 1 ppm to protect flying birds and less than 2 ppm to protect resting mammals from hydrogen sulfide toxicity in their habitat. These recommendations would be considered "action levels" as they do not consider a number of uncertainty factors normally used in the derivation of ambient air quality criteria (USEPA 1994, 2003).

Sias and Snell (1998) hypothesized that since sand dune lizards are strongly associated with the bottoms of dune valleys, these lizards may be more susceptible to gas poisoning (than other lizard species) associated with these wells since hydrogen sulfide is heavier than air. Sias and Snell (1996, 1998) provided data and evidence to conclude that the presence of oil and gas wells is strongly correlated with a reduction in sand dune lizard abundance. Their plots within 263 ft (80 m) of an oil or gas well pad (the area of disturbance around a well) had a 39 percent reduction in the population of sand dune lizards compared with plots more than 623 ft (190 m) from an oil or gas well pad. Sias and Snell (1998) also identified impacts to other wildlife including observations of moribund owls and other raptors as well as they found the carapace remains of turtle carcasses (*e.g.* turtle shells) in areas around oil and gas wells that were reported to emit hydrogen sulfide and other gases (identified by signage).

We found that sand dune lizards that are active should begin to demonstrate adverse effects at concentrations in their environment greater than 14 ppm. On February 2, 2003, we measured hydrogen sulfide concentrations as high as 26 ppm for 1 h in the early evening (Figure 22) with little or no wind measured nearby. On March 25, 2003, we measured hydrogen sulfide concentrations as high as 33 ppm for 32 min in the early morning with winds measured nearby approaching 17 mi/h (~27 km/h) from the north (Figure 22). These ambient concentrations during these periods were at levels that would be expected to have adverse effects on active sand dune lizards and perhaps other wildlife species as well (Table 2). Sand dune lizards that are resting should be protected from adverse effects of hydrogen sulfide if concentrations in their environment remain below 50 ppm. No ambient hydrogen sulfide concentrations above 50 ppm were measured during this study.

Other studies have found that habitat disrupted by oil and gas activities negatively impacts populations of birds. Migration routes of waterfowl are often changed and the breeding success of waterfowl decreases as a result of oil and gas activities (Monda *et al.* 1994; Johnson 1998). Populations of birds of prey dramatically decrease when oil wells are placed within habitat they occupy (Squires *et al.* 1993; Van Horn 1993). Many species of passerines have also been impacted negatively by the building of oil well sites (Baker 1987).

In this study, there was a statistical difference in the average number of individuals counted per point count, the average number of species counted per point count survey, the species composition, and the average concentration of hydrogen sulfide at the undisturbed and the disturbed sites. This suggests that habitat quality may be affected by oil and gas activities and may alter the composition of local avian communities. Habitat disrupted by oil and gas activities favored avian species adapted to feeding in disturbed habitat such as doves, quail, and sparrows. Habitat disturbed by oil and gas activities contained fewer species and reduced usage by species such as wrens, vireos, flycatchers and phoebes.

It is possible that oil and gas activities may negatively affect avian diversity and their numbers through changes in vegetation that were not quantified during this study. However, we found that changes in habitat conditions as described as "disturbed" by oil and gas activities, were significantly related to reduced numbers of birds observed during point counts, decreased avian species diversity observed during point counts, and increased hydrogen sulfide concentrations. Nonetheless, the causes of the decline of bird density, diversity and elevated hydrogen sulfide were not determined during this study. Further long-term studies of the effects of oil and gas activities on migratory birds and their habitat are needed. Restoration of habitat affected by activities of oil and gas is needed to preserve migratory bird populations and avian species diversity.

RECOMMENDATIONS

The authors recommend that Federal, State and Tribal agencies implement the following actions to protect wildlife:

1. Adopt an interim air quality standard of 1 ppm hydrogen sulfide to protect wildlife.

2. Require monitoring of hydrogen sulfide to identify sources in areas where ambient concentrations routinely exceed 1 ppm and find ways to reduce those sources. Routine monitoring should include appropriate meteorological monitoring, particularly local wind conditions and direction, so as to identify any seasonal or geographic trends. Hydrogen sulfide monitoring programs should be adequate to characterize a geographic area and its ambient conditions over time, as well as be able to identify any local sources for management actions.

3. Report incidences of migratory bird deaths to the Service, as may occur when birds are affected by oil and gas activities, hydrogen sulfide emissions or release of other hazardous fluids. Federal, State and Tribal agencies should identify any means and measures necessary to avoid or minimize the potential for take of migratory birds.

4. Fund studies that confirm the toxicity and mechanisms of action of hydrogen sulfide using mammal, avian and reptile species in order to refine this risk assessment in this study as well as identify any adverse effects to their olfactory tissues and functions.

5. Routinely monitor avian communities in habitats that are affected by oil and gas activities in order to determine any long-term deleterious trends and develop management strategies to address those trends to conserve migratory bird habitats.

6. Evaluate the changes to the vegetative community by oil and gas activities and any associated surface waters for effects to migratory birds, and other wildlife.

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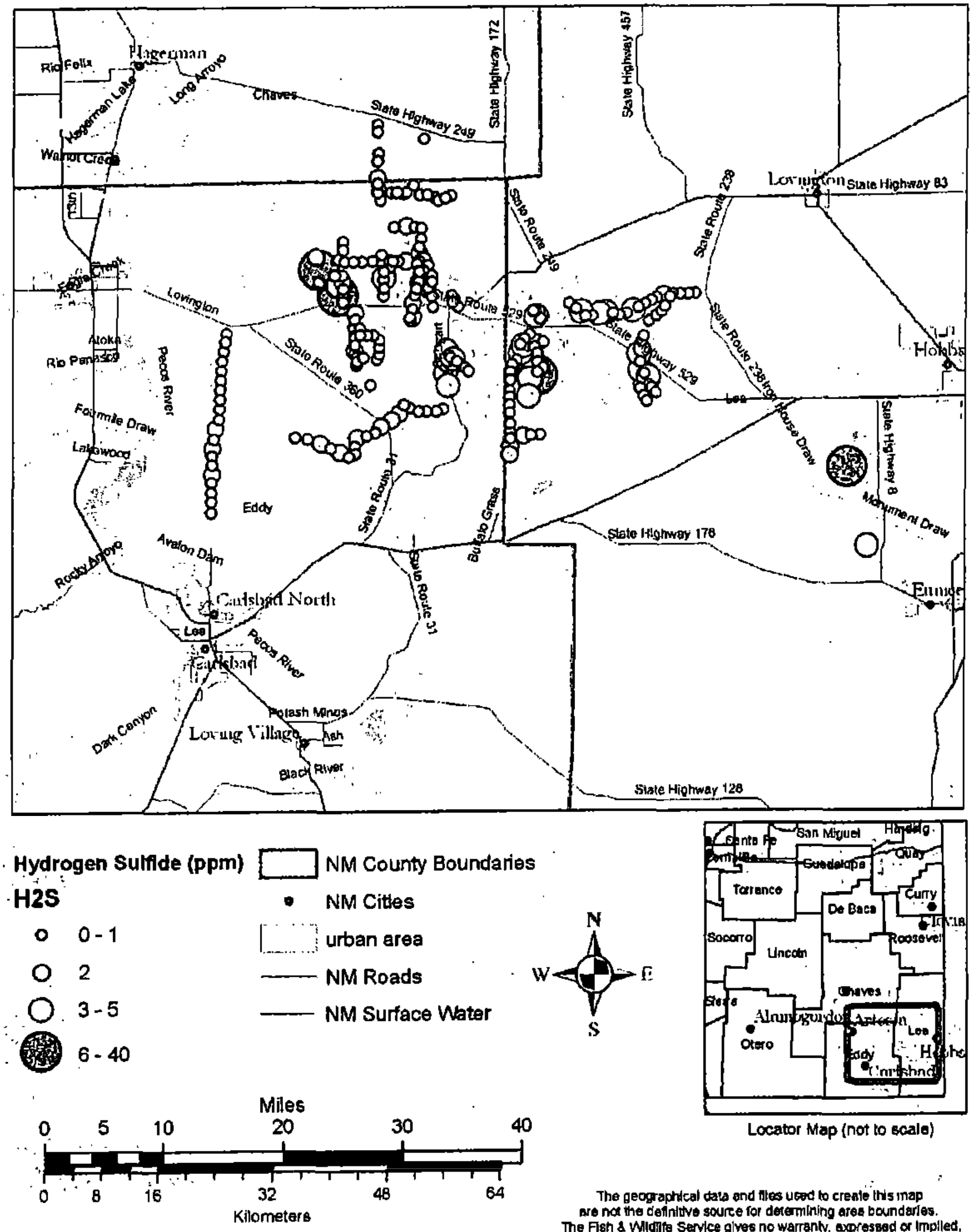

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Figure 1. Map of the Study Area and Hydrogen Sulfide Monitoring Results

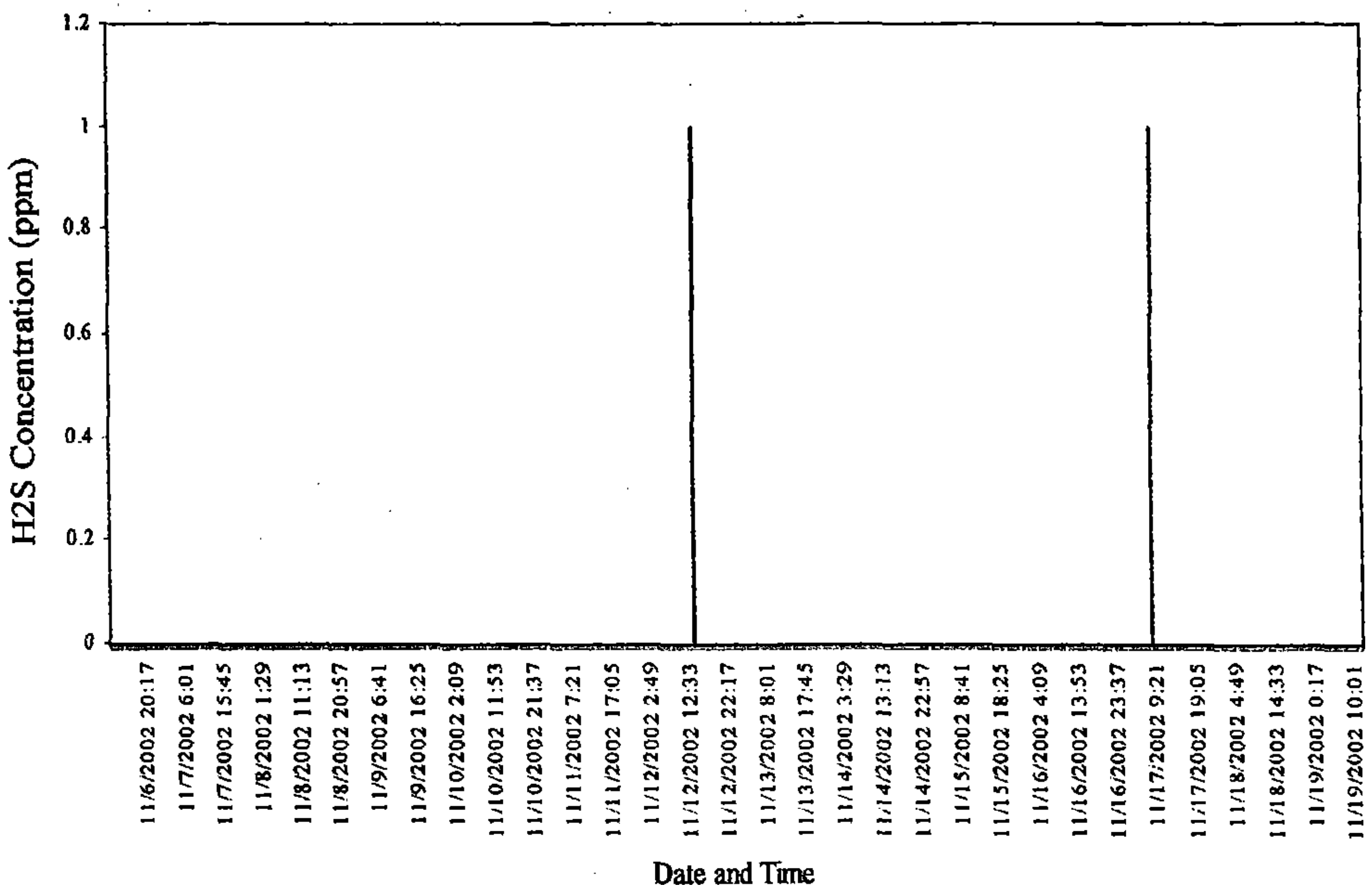

Figure 2. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 50' 10" by West 103 ° 58' 39") for November 6, 2002- November 19, 2002.

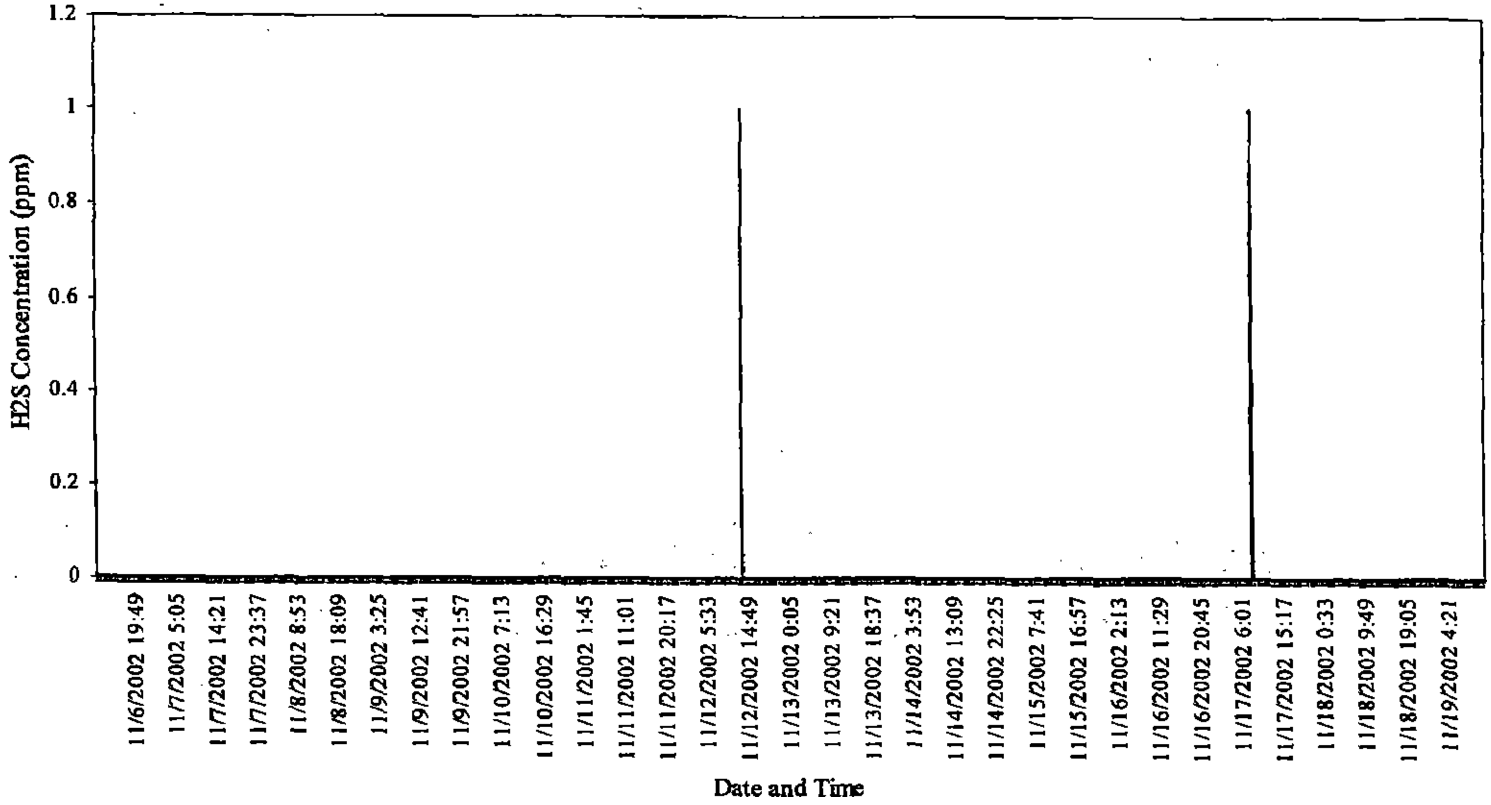

Figure 3. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 27' 05" by West 104 ° 31' 29") for November 6, 2002- November 19, 2002.

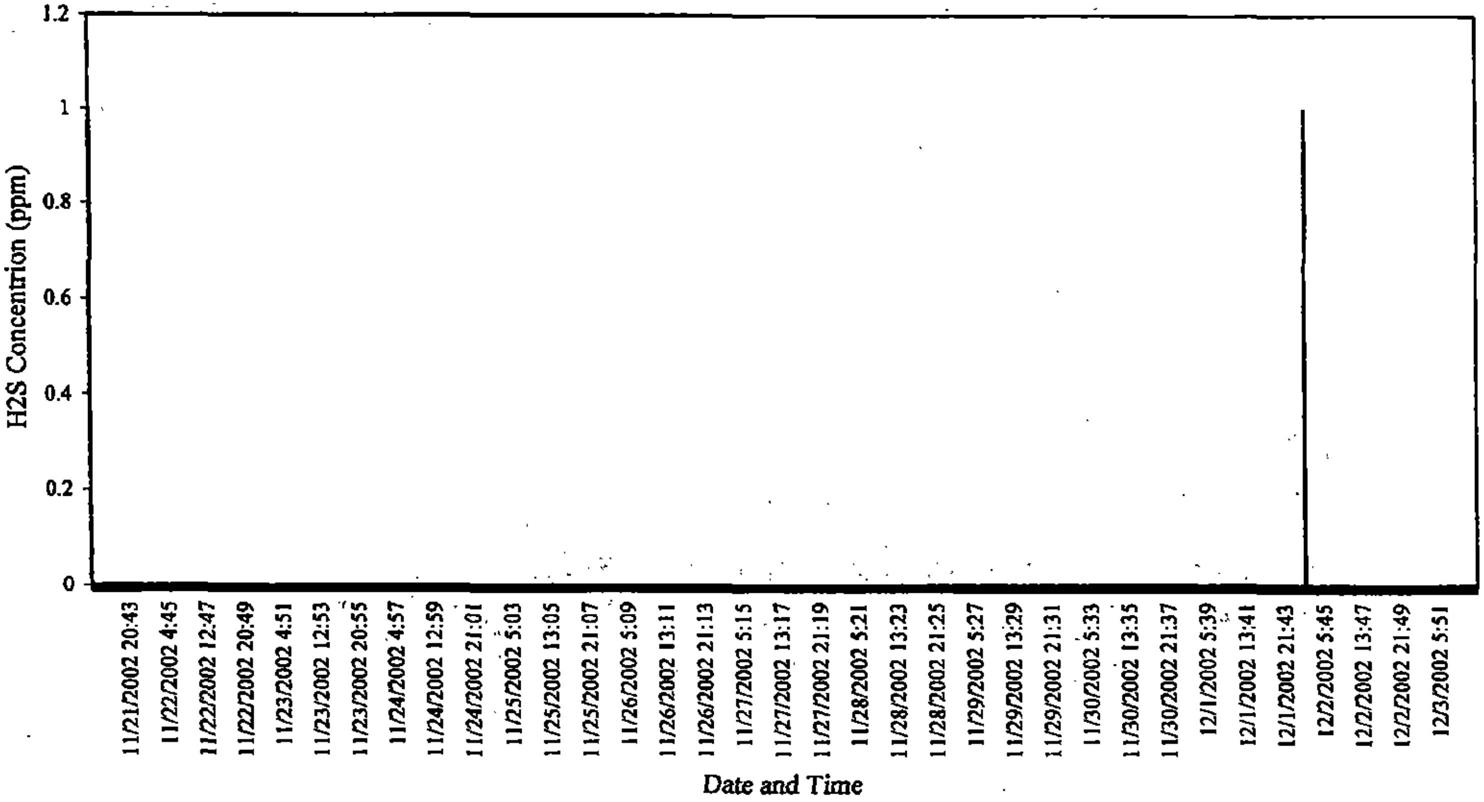

Figure 4. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 60' 17" by West 104 ° 36' 34") for November 21, 2002- December 3, 2002.

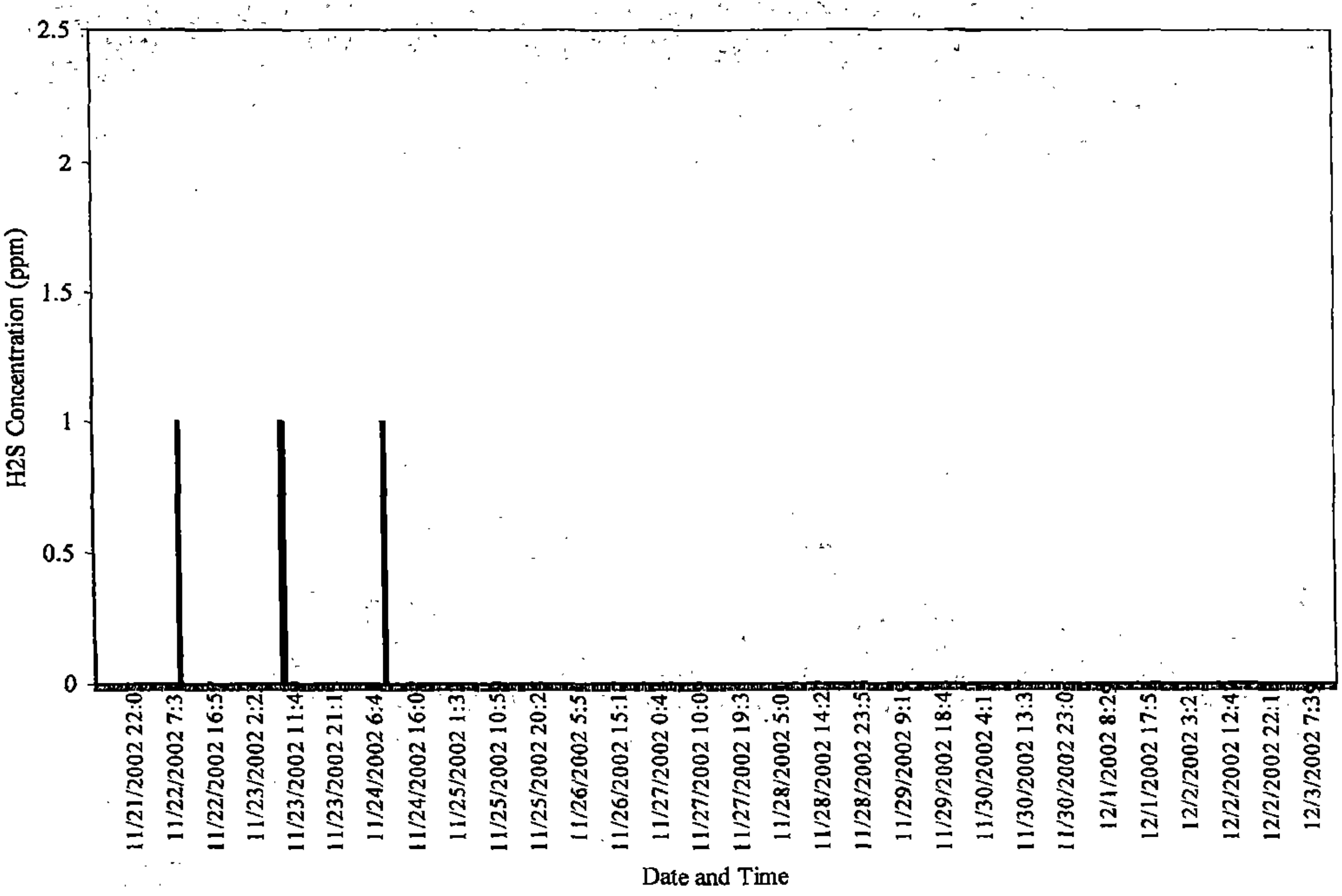

Figure 5. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 33 ° 59' 04" by West 104 ° 36' 34") for November 21, 2002- December 3, 2002.

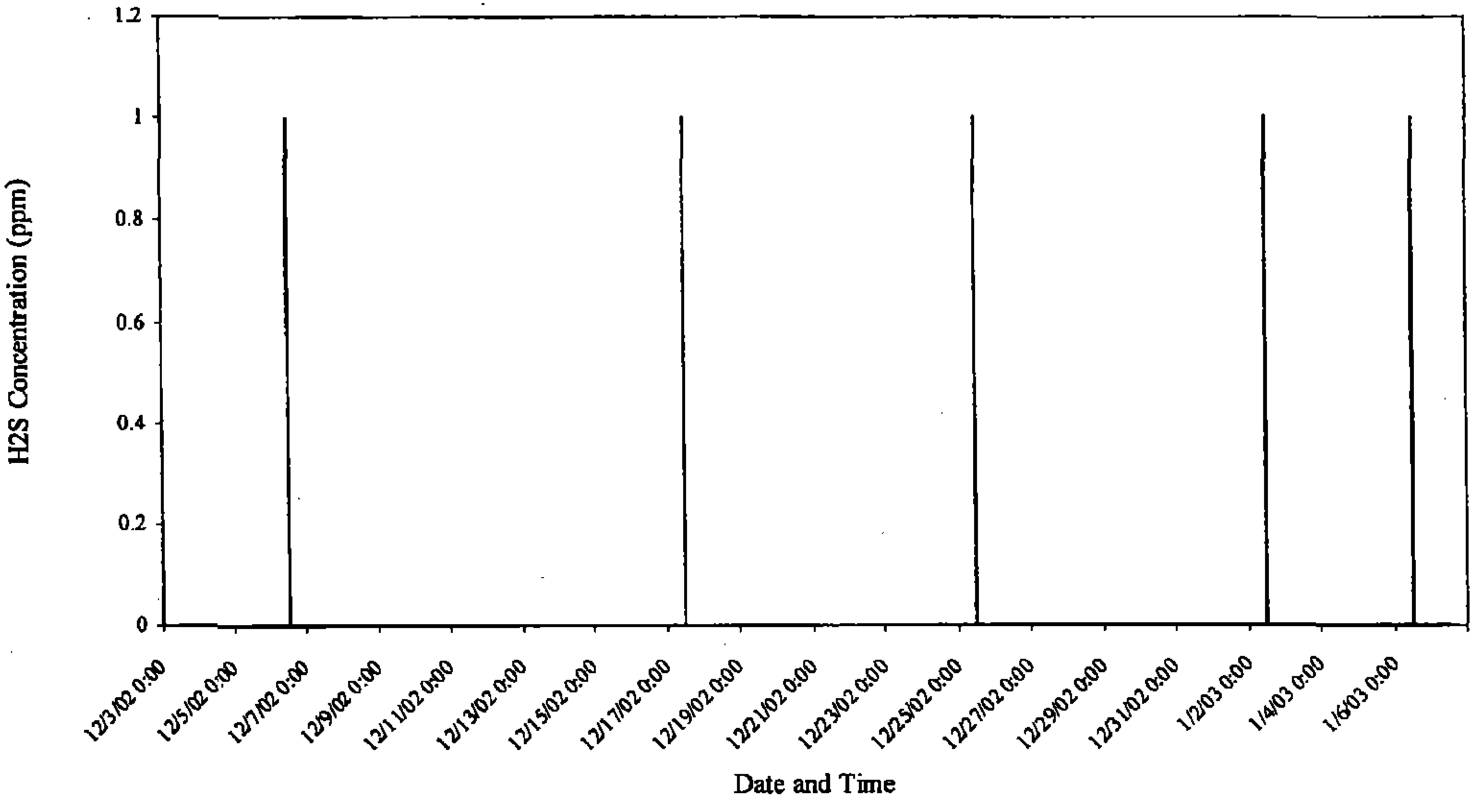

Figure 6. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 33 ° 50' 45" by West 104° 05' 56") for December 6, 2002- January 7, 2003.

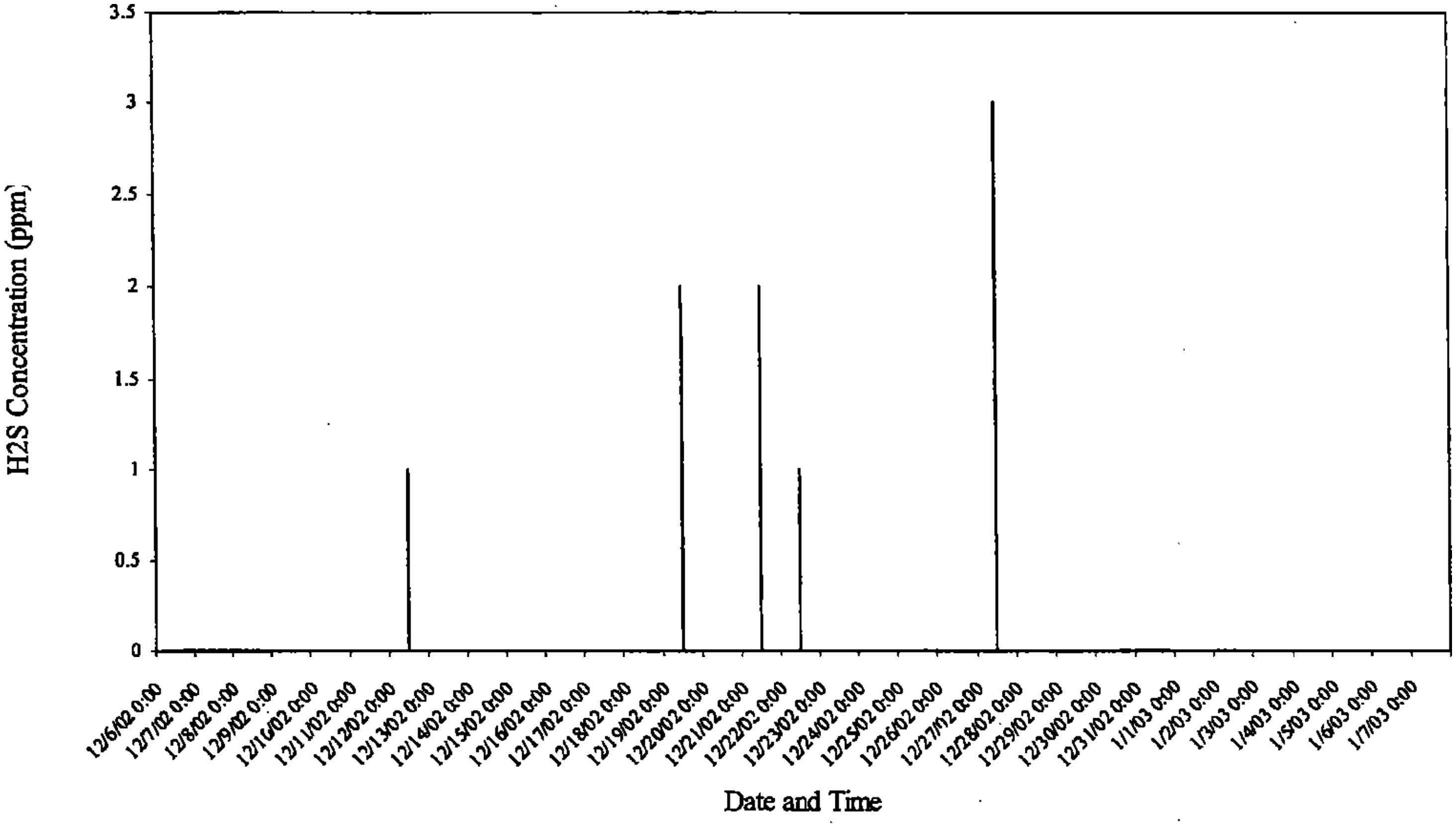

Figure 7. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 51' 10" by West 103 ° 58' 39") for December 6, 2002- January 7, 2003.

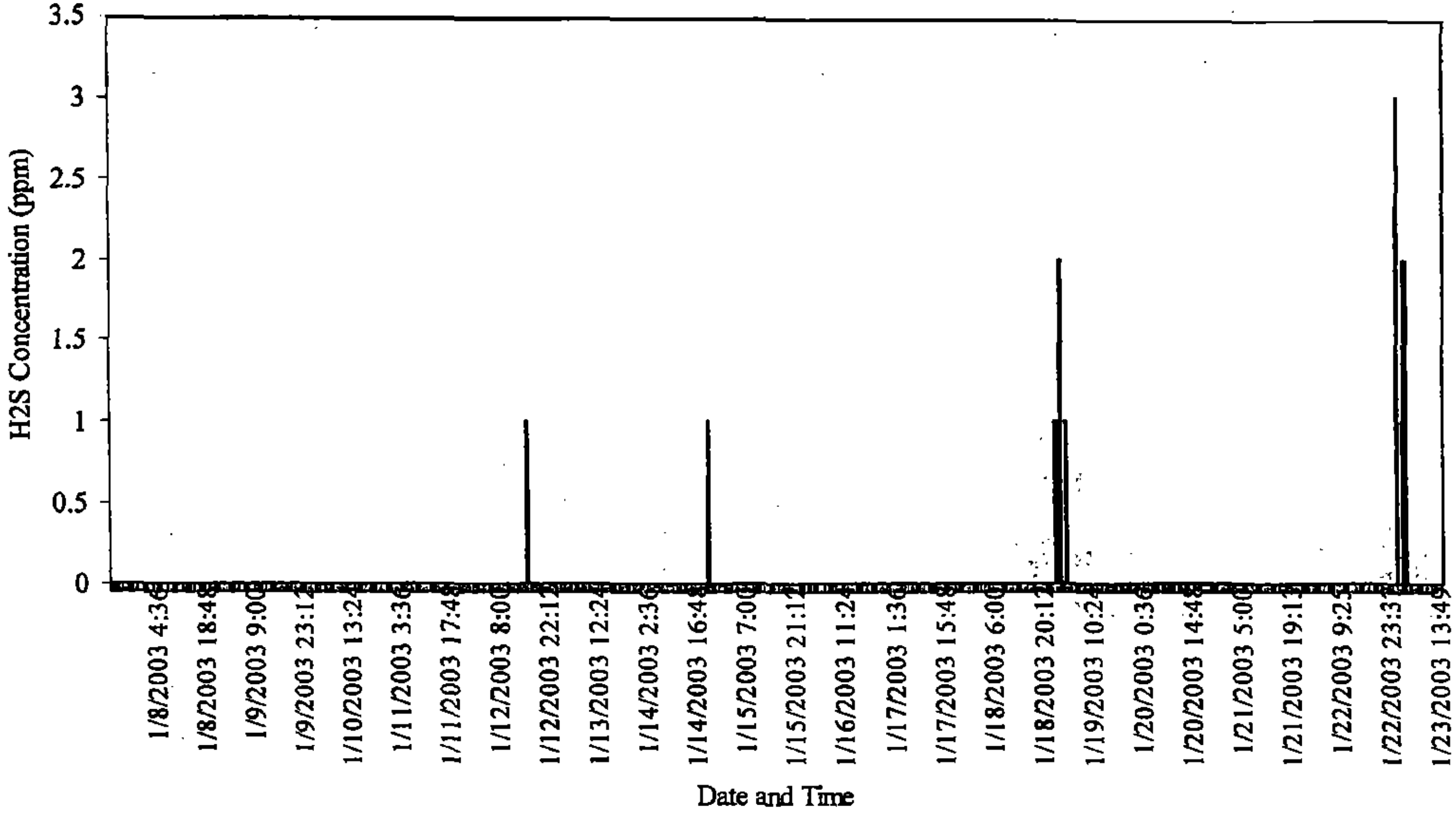

Figure 8. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 50' 37" by West 104 ° 02' 37") for January 7, 2003- January 23, 2003.

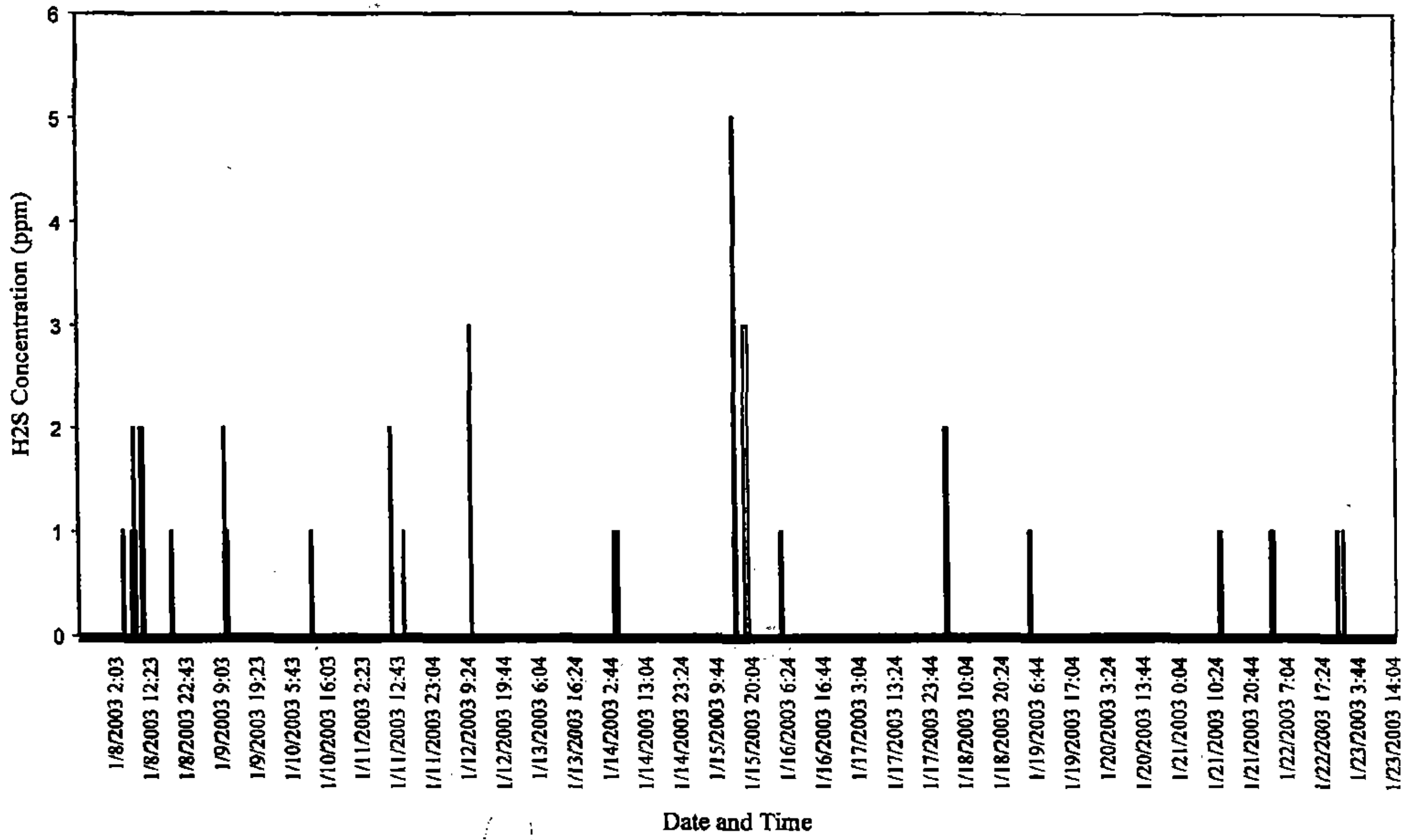

Figure 9. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 31' 01" by West 103 ° 16' 59") for January 7, 2003- January 23, 2003.

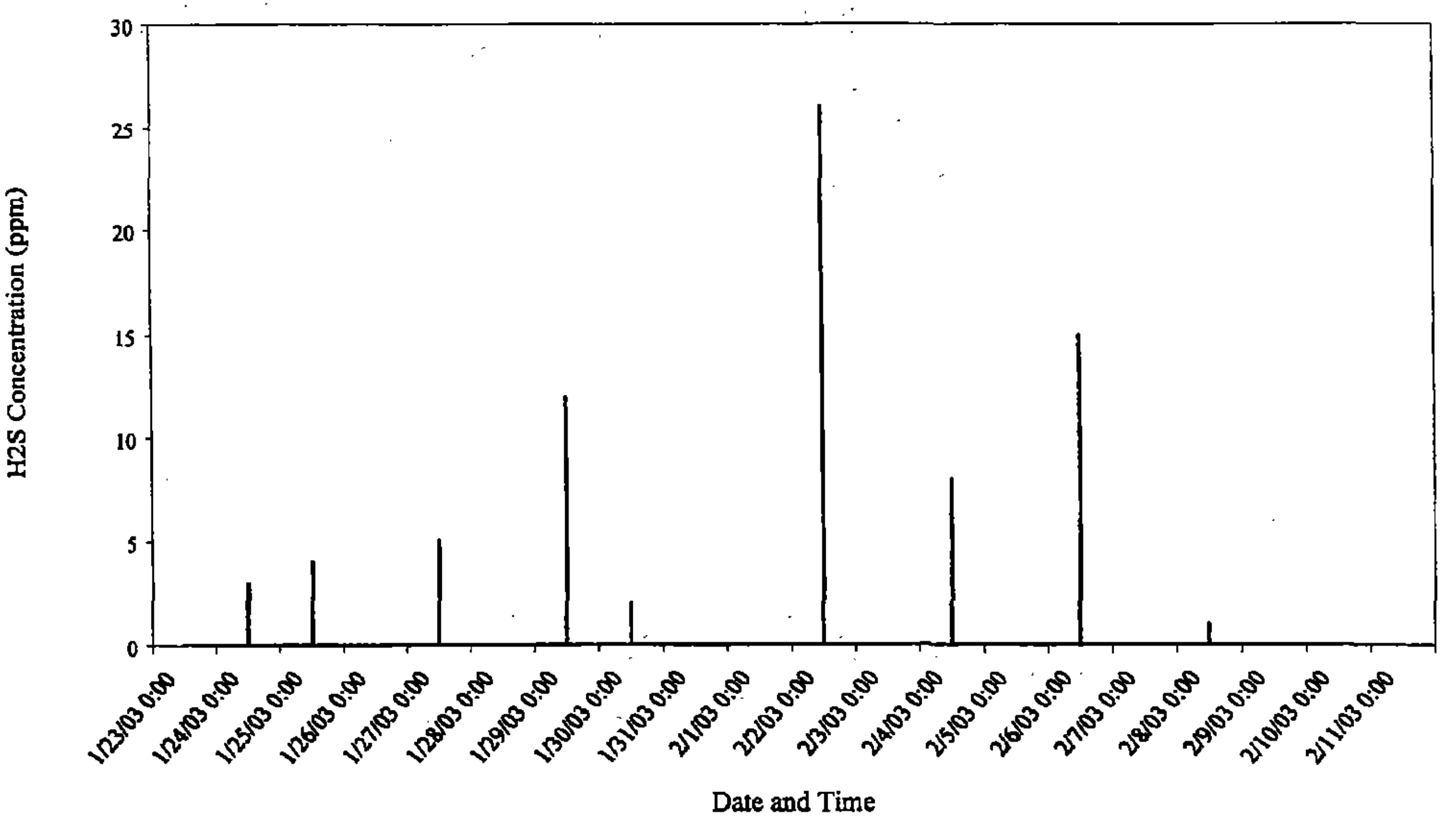

Figure 10. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 36' 48" by West 103 ° 18' 44") for January 23, 2003- February 11, 2003.

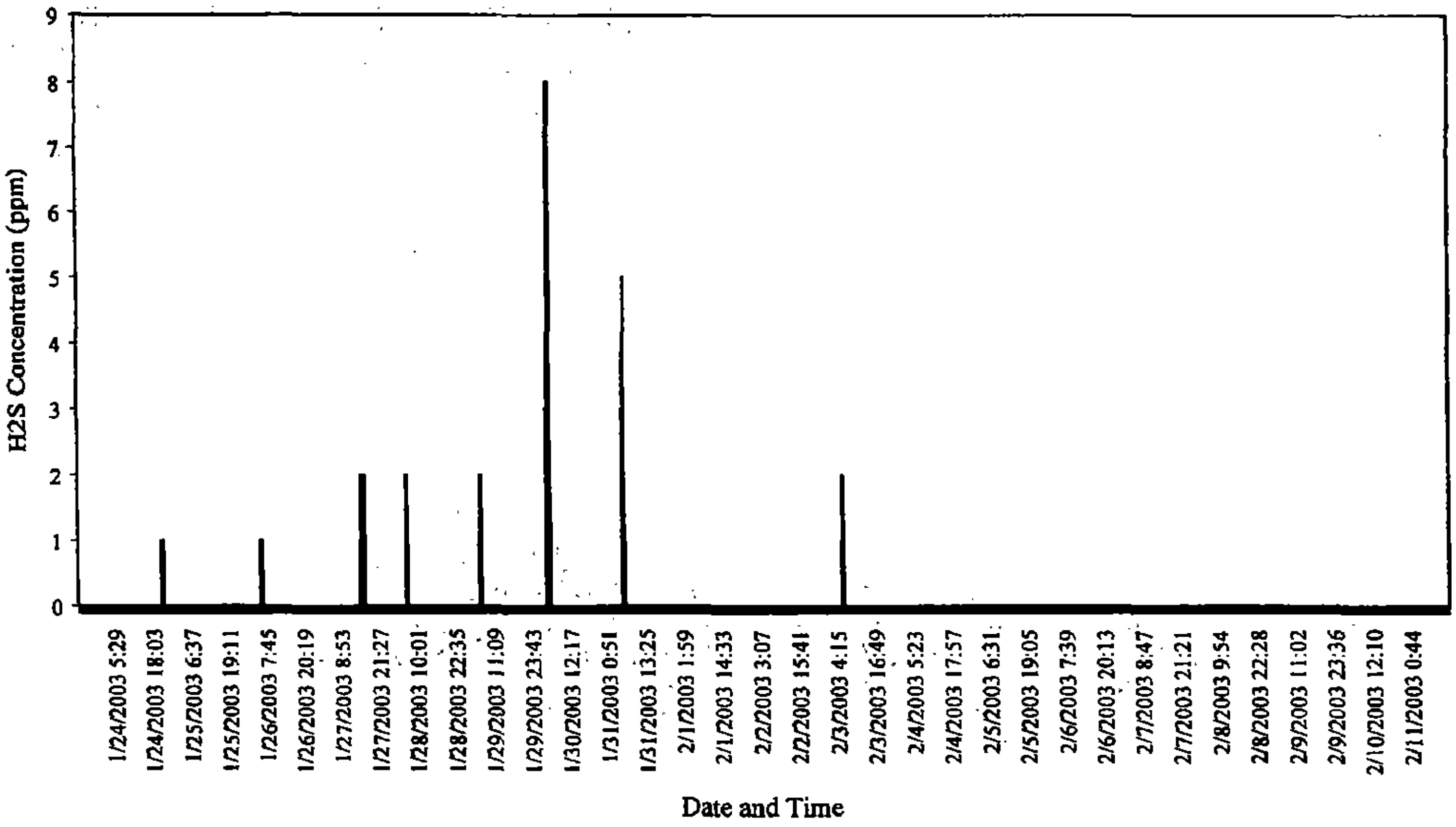

Figure 11. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 51' 46" by West 104 ° 04' 16") for January 23, 2003- February 11, 2003.

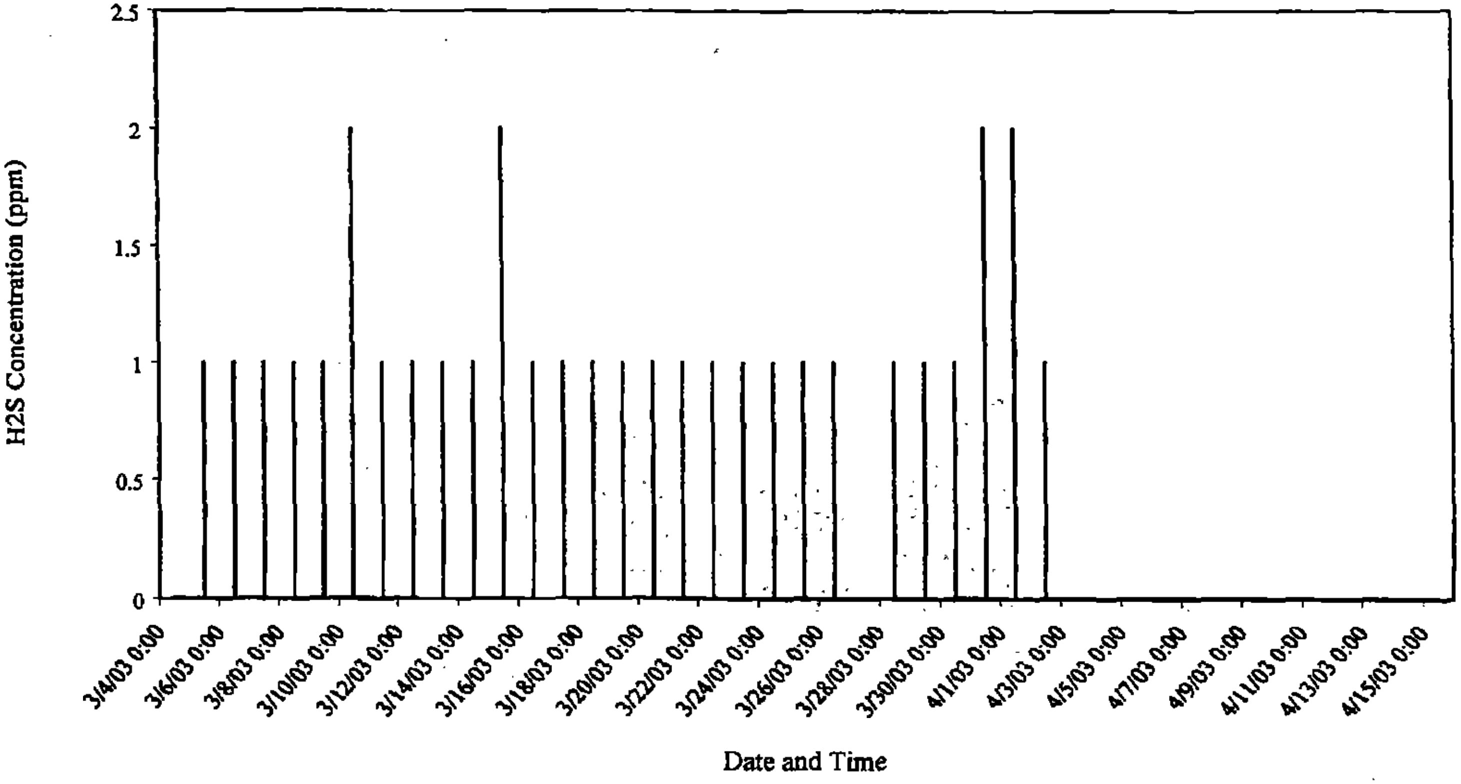

Figure 12. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32 ° 52' 43" by West 104 ° 04' 32") for March 4, 2003- April 16, 2003.

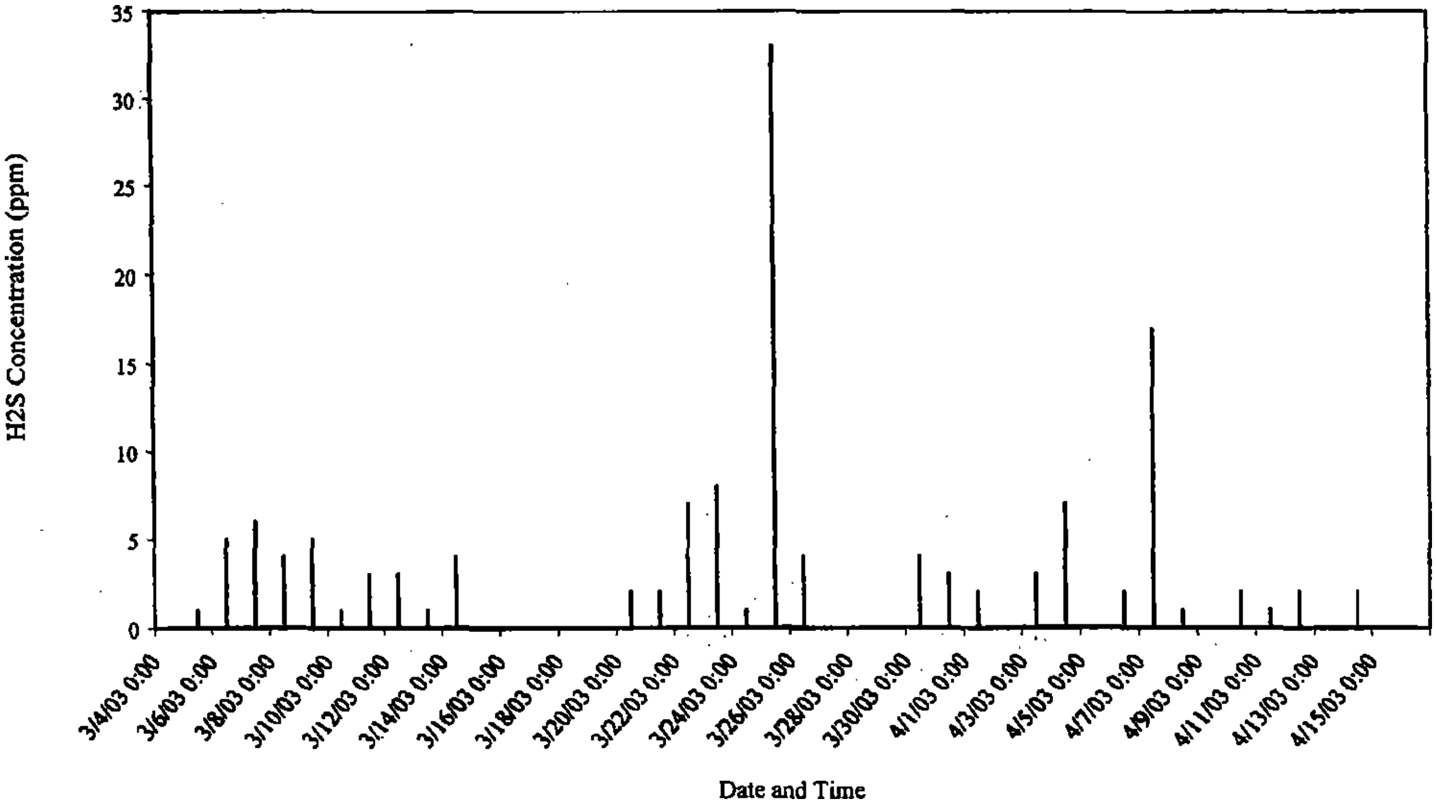

Figure 13. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32 ° 49' 54" by West 104 ° 02' 41") for March 4, 2003- April 16, 2003.

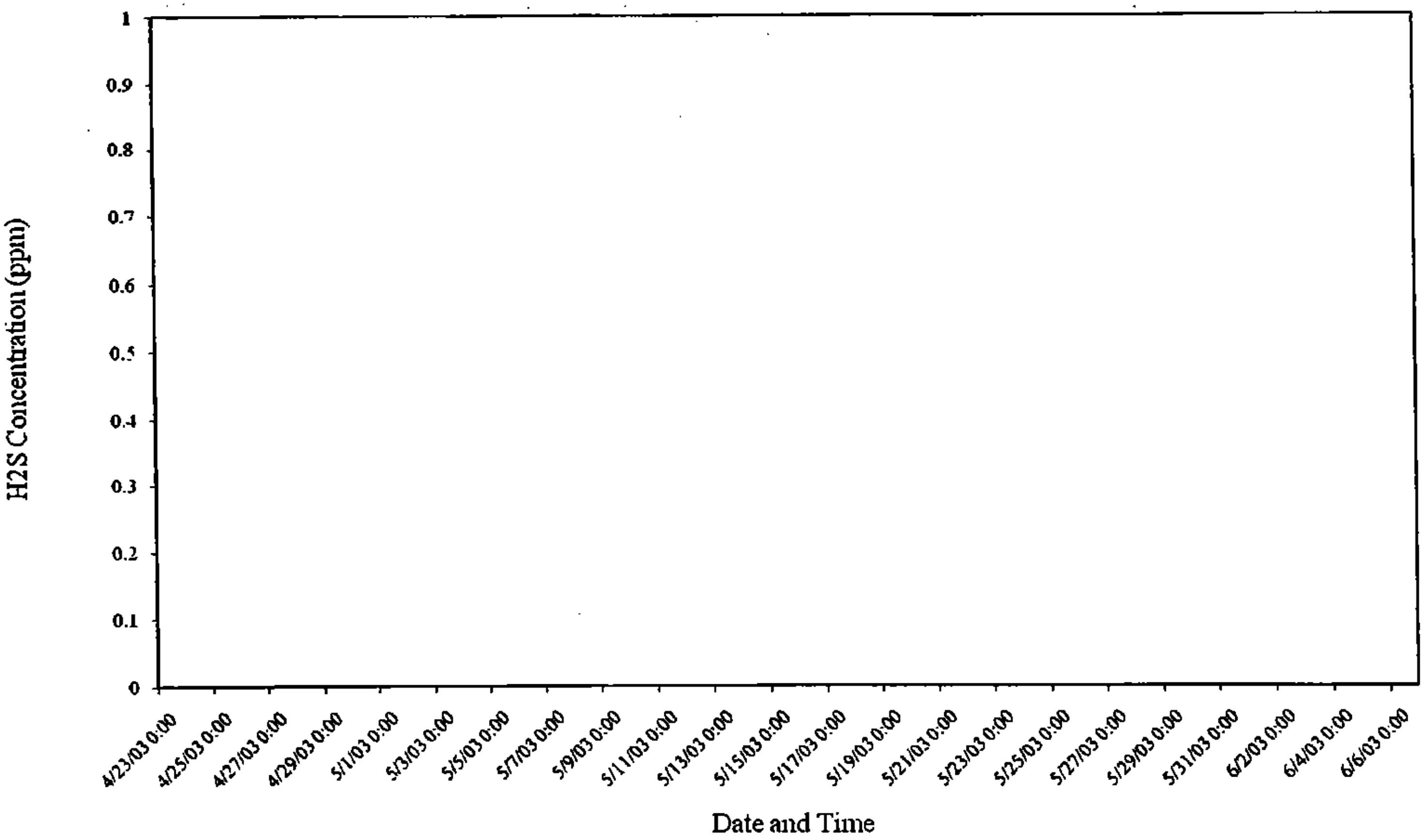

Figure 14. Graph of Hydrogen Sulfide Concentrations near Mathers Natural Area (North 32° 48' 14" by West 103° 56' 27") for April 23, 2003- June 28, 2003. [Note: concentration of hydrogen sulfide measured in ambient air for 65 days at this site was zero.]

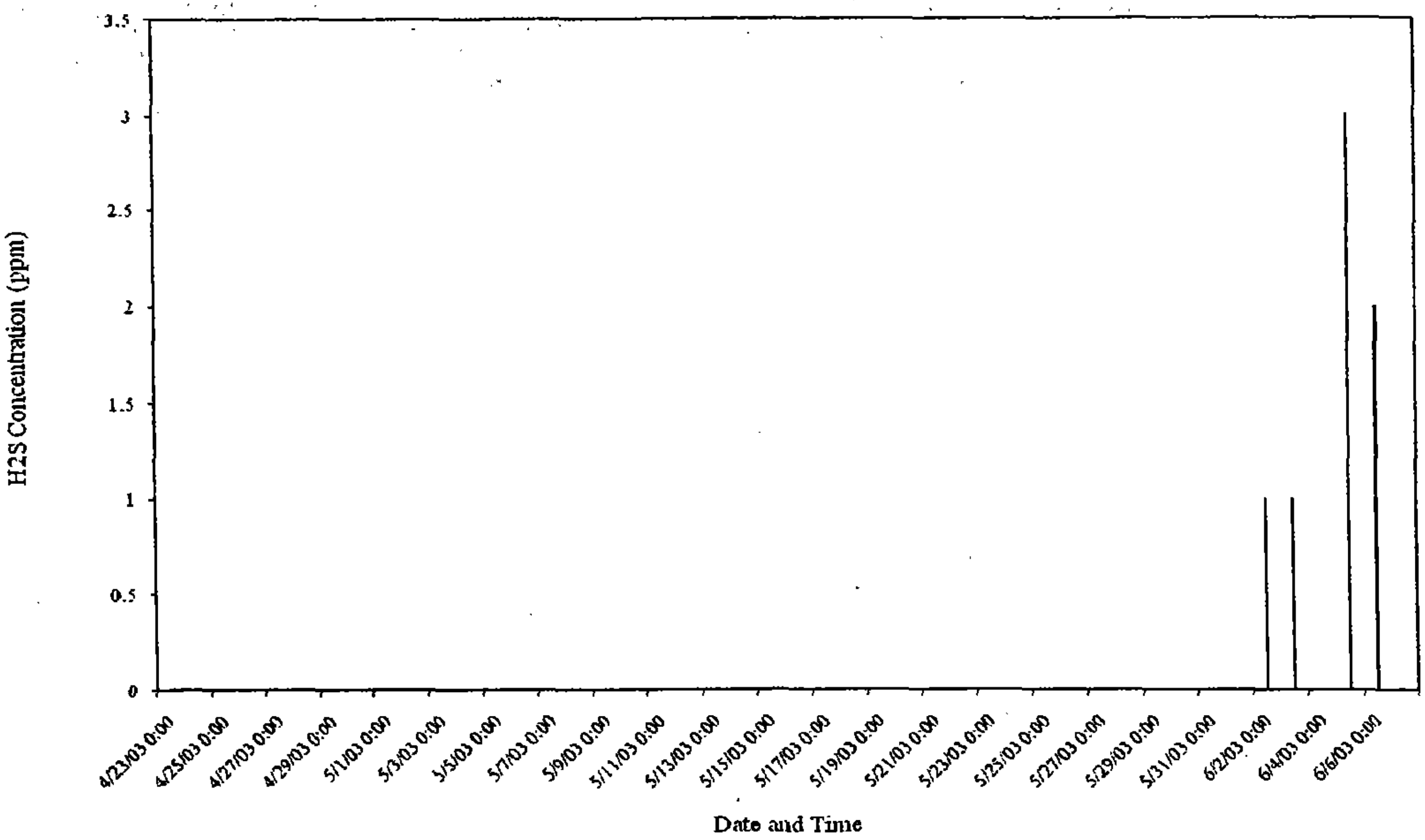

Figure 15. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32° 42' 21" by West 103° 46' 12") for April 23, 2003- June 28, 2003.

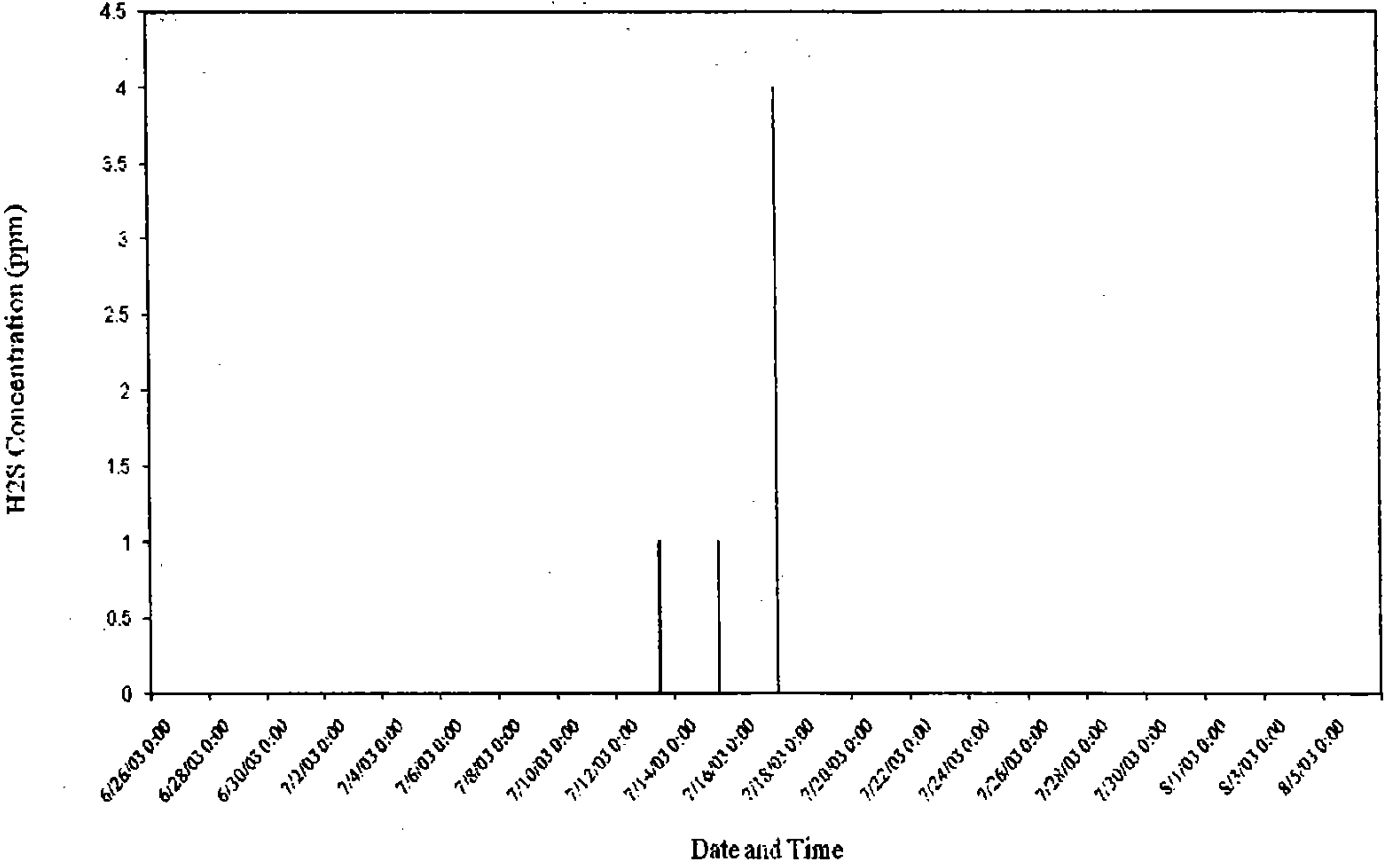

Figure 16. Graph of Hydrogen Sulfide Concentrations near an Oil Storage Tank (North 32° 48' 10" by West 103° 45' 31") for June 28, 2003- August 6, 2003.

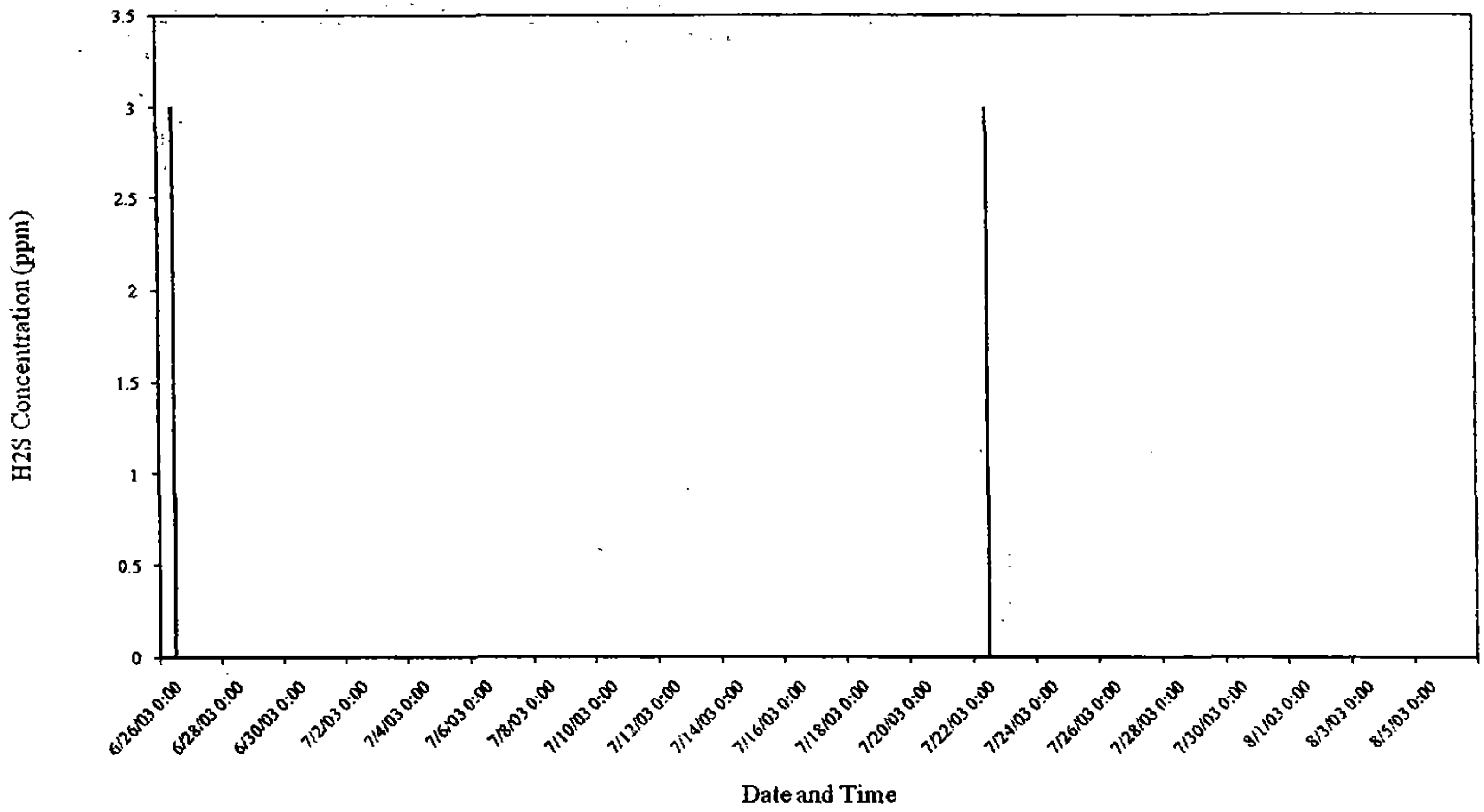

Figure 17. Graph of Hydrogen Sulfide Concentrations near an Oil Well (North 32° 45' 16" by West 103° 36' 39") for June 28, 2003- August 6, 2003.

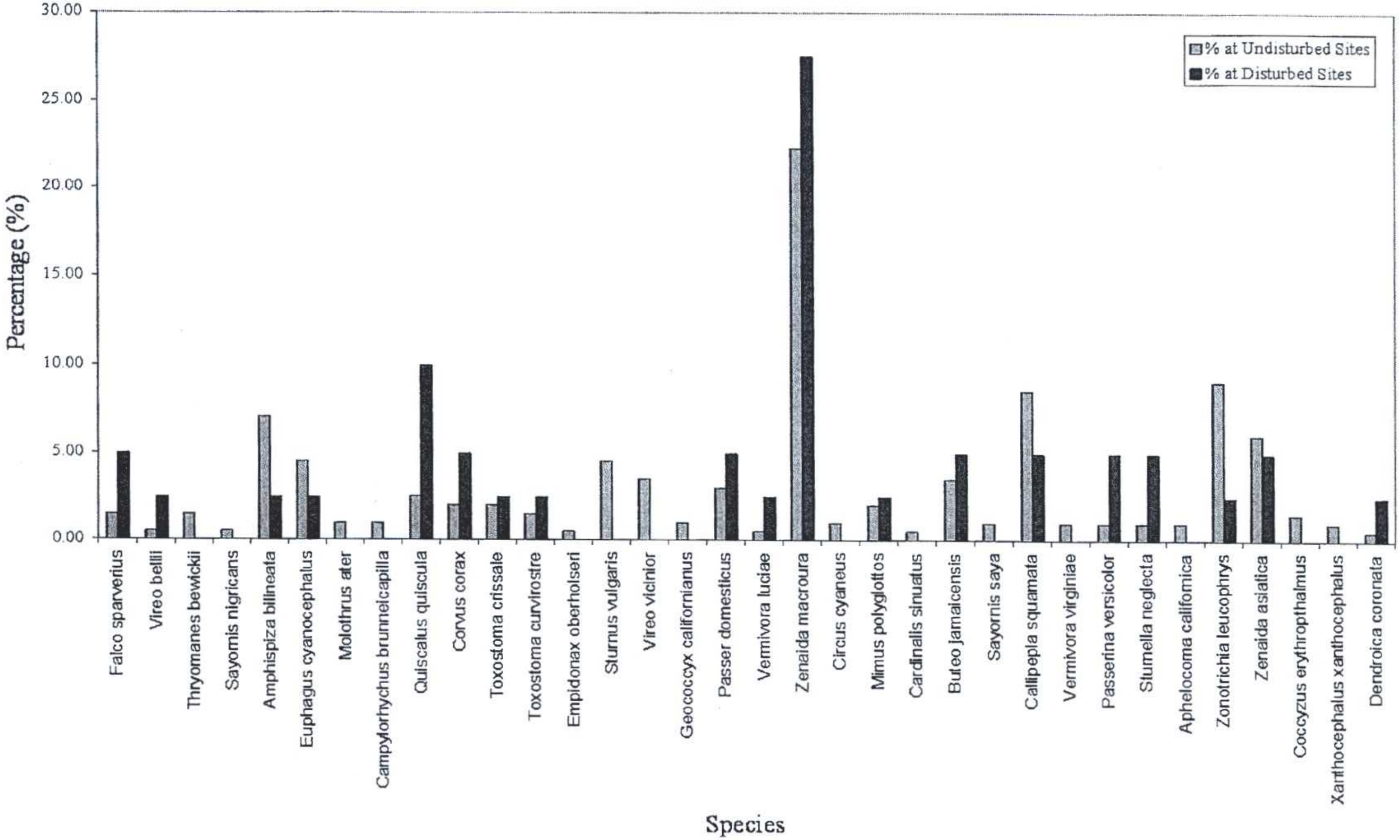

Figure 18. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Winter Survey Season.

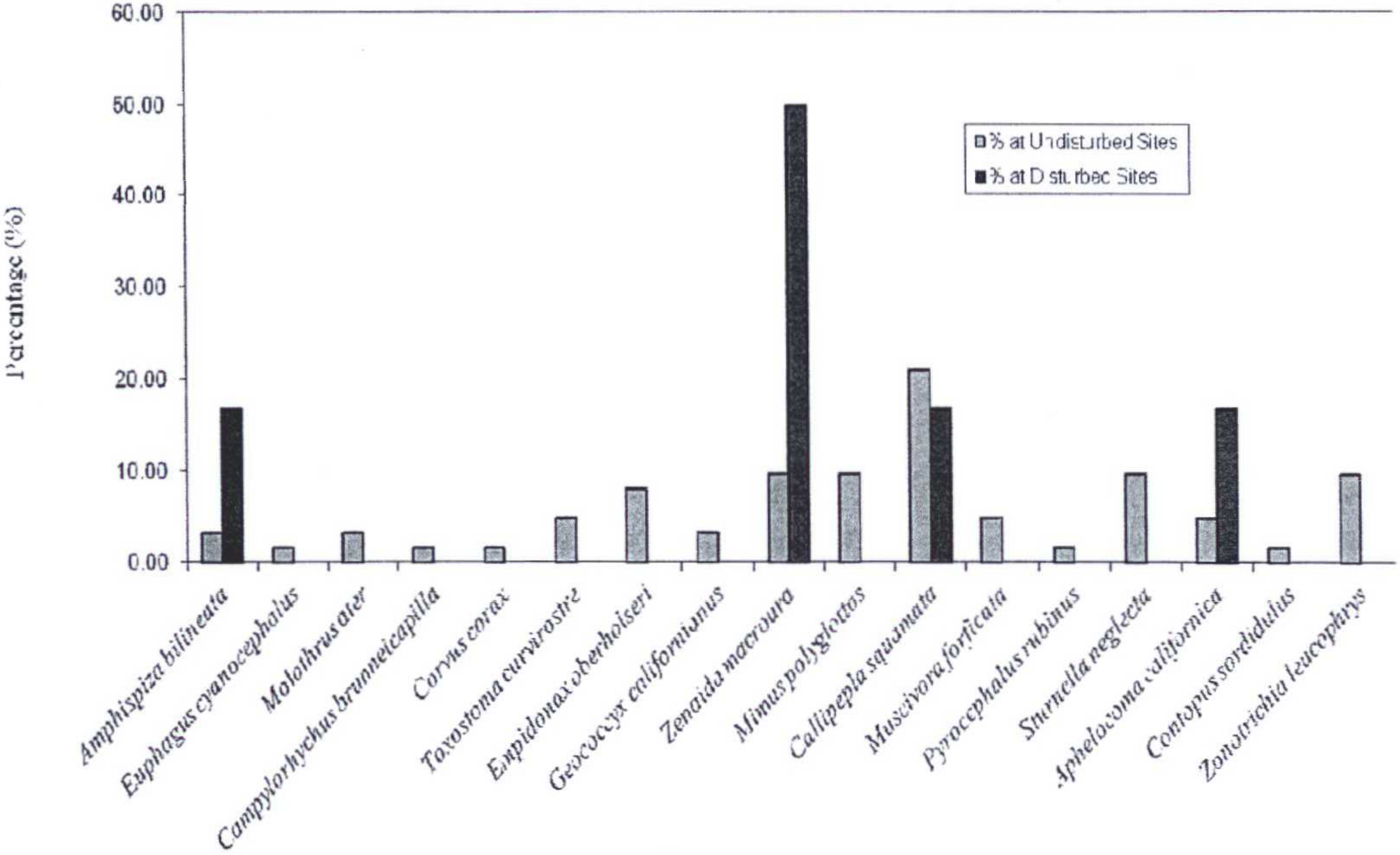

Figure 19. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Spring Survey Season.

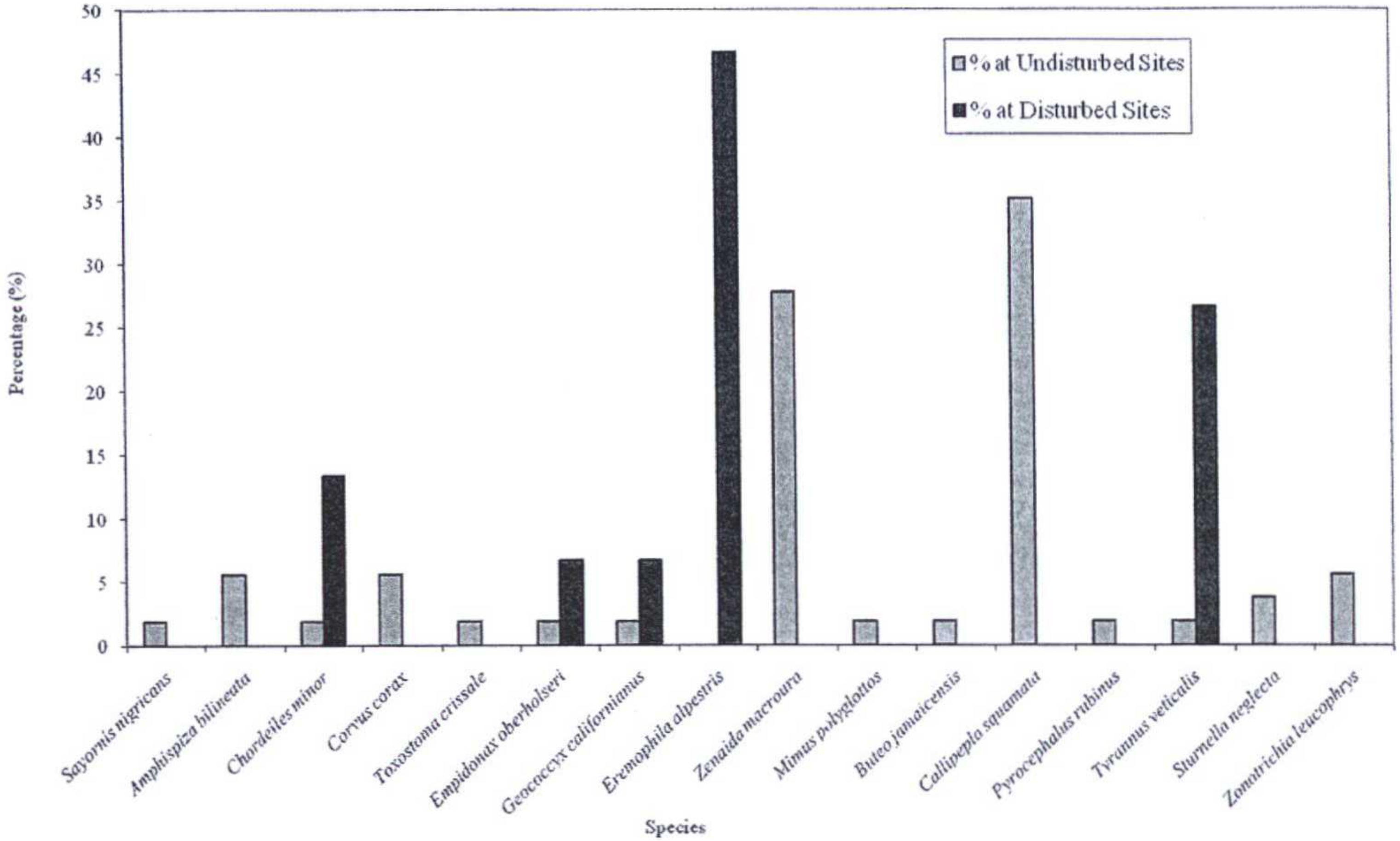

Figure 20. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Summer Survey Season.

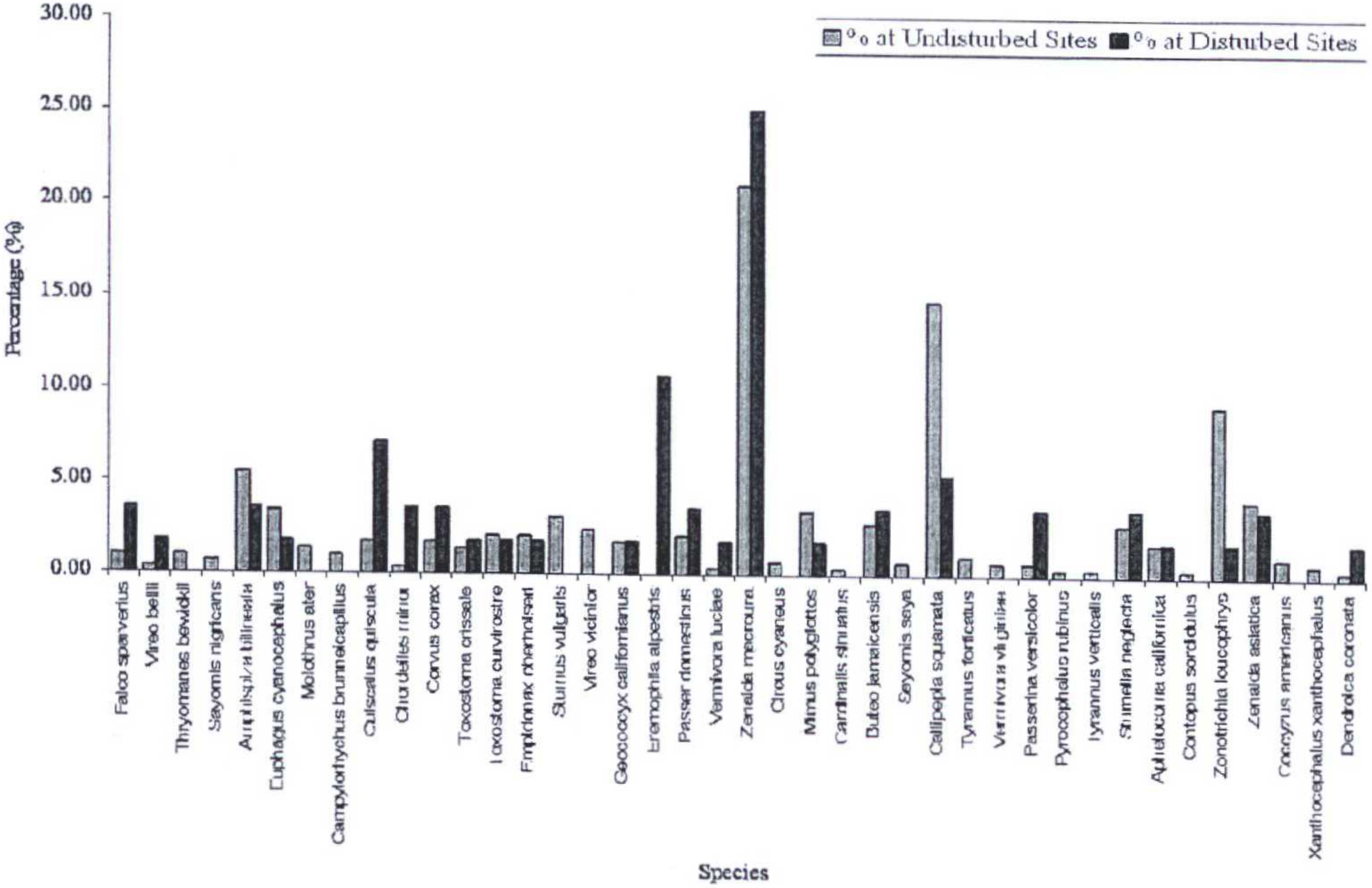

Figure 21. Graph of Species Composition Present at Undisturbed and Disturbed Sites for the Entire Survey Season.

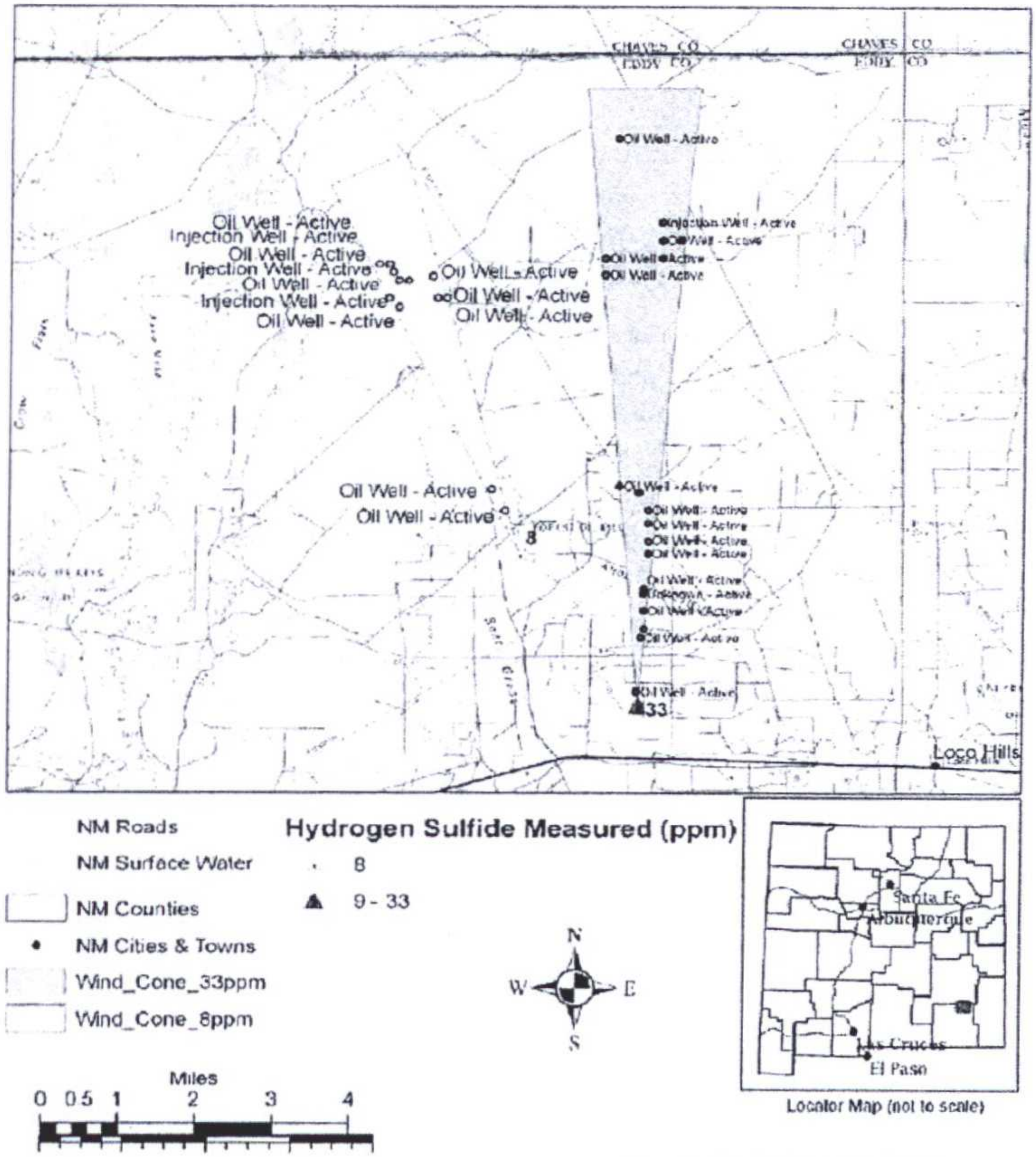

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Figure 22. Potential Sources of Hydrogen Sulfide in a "Wind Cone" based on nearby Wind Speed and Direction towards the Measured Hydrogen Sulfide Concentration. Any One or a Combination of Marked Active Wells could be the Source of the Hydrogen Sulfide.

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Amphibians	Scientific Name
Couch's Spadefoot	*Scaphiopus couchii*
Plains Spadefoot	*Spea bombifrons*
New Mexico Spadefoot	*Spea multiplicata*
Reptiles	
Eastern Glossy Snake	*Arizona elegans*
Chihuahuan Spotted Whiptail	*Aspidoscelis exsanguis*
Prairie Racerunner	*Cnemidophorus sexlineata viridis*
Greater Earless Lizard	*Cophosaurus texanus*
Western Diamondback Rattlesnake	*Crotalus atrox*
Prairie Rattlesnake	*Crotalus viridis*
Eastern Collared Lizard	*Crotaphytus collaris*
Ringneck Snake	*Diadophis punctatus*
Longnose Leopard Lizard	*Gambelia wislizenii*
Western Hognose Snake	*Heterodon nasicus*
Lesser Earless Lizard	*Holbrookia maculata*
Chihuahuan Night Snake	*Hypsiglena jani*
Desert Kingsnake	*Lampropeltis getula splendida*
Milk Snake	*Lampropeltis triangulum*
New Mexico Blind Snake	*Leptotyphlops dissectus*
Coachwhip	*Masticophis flagellum*
Texas Horned Lizard	*Phrynosoma cornutum*
Roundtail Horned Lizard	*Phrynosoma modestum*
Gopher Snake	*Pituophis catenifer*
Great Plains Skink	*Plestiodon obsoletus*
Longnose Snake	*Rhinocheilus lecontei*
Sand Dune Lizard	*Sceloporus arenicolus*
Eastern Fence Lizard	*Sceloporus undulatus*
Desert Massasauga	*Sistrurus catenatus edwardsii*
Ground Snake	*Sonora semiannulata*
Plains Blackhead Snake	*Tantilla nigriceps*
Ornate Box Turtle	*Terrapene ornata*
Side-blotched Lizard	*Uta stansburiana*
Birds	
Red-winged Blackbird	*Agelaius phoeniceus*
Cassin's Sparrow	*Aimophila cassinii*
Grasshopper Sparrow	*Ammodramus savannarum*
Burrowing Owl	*Athene cunicularia*
Great horned Owl	*Bubo virginianus*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Swainson's Hawk	*Buteo swainsoni*

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Scaled Quail	*Callipepla squamata*
House Finch	*Carpodacus mexicanus*
Turkey Vulture	*Cathartes aura*
Killdeer	*Charadrius vociferus*
Lark Sparrow	*Chondestes grammacus*
Common Nighthawk	*Chordeiles minor*
Northern Bobwhite	*Colinus virginianus*
Chihuahuan Raven	*Corvus cryptoleucus*
Horned Lark	*Eremophila alpestris*
American Kestrel	*Falco sparverius*
Greater Roadrunner	*Geococcyx californianus*
Barn Swallow	*Hirundo rustica*
Bullock's Oriole	*Icterus bullockii*
Dark-eyed Junco	*Junco hyemalis*
Loggerhead Shrike	*Lanius ludovicianus*
Northern Mockingbird	*Mimus polyglottos*
Brown-headed Cowbird	*Molothrus ater*
Ash-throated Flycatcher	*Myiarchus cinerascens*
House Sparrow	*Passer domesticus*
Blue Grosbeak	*Passerina caerulea*
Great-tailed Grackle	*Quiscalus mexicanus*
Common Grackle	*Quiscalus quiscula*
Lesser Goldfinch	*Spinus psaltria*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Sturnella neglecta*
European Starling	*Sturnus vulgaris*
Curve-billed Thrasher	*Toxostoma curvirostre*
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Western Kingbird	*Tyrannus verticalis*
Barn Owl	*Tyto alba*
Mourning Dove	*Zenaida macroura*
Mammals	
Pallid bat	*Antrozous pallidus*
Coyote	*Canis latrans*
Townsend's big-eared bat	*Corynorhinus townsendii*
Ord's Kangaroo Rat	*Dipodomys ordii*
Big brown bat	*Eptesicus fuscus*
Silver-haired bat	*Lasionycteris noctivagans*
Red bat	*Lasiurus blossevillii*
Hoary bat	*Lasiurus cinereus*
California myotis	*Myotis californicus*

Table 1. Common and Scientific Names of Selected Wildlife Species found in the Sand Shinnery Community of the Mescalero Sands in Southeast New Mexico.

Western small-footed myotis	*Myotis ciliolabrum*
Fringed myotis	*Myotis thysanodes*
Cave myotis	*Myotis velifer*
Long-legged myotis	*Myotis volans*
Yuma Myotis	*Myotis yumanensis*
Pocketed free-tailed bat	*Nyctinomops femorosacca*
Big free-tailed bat	*Nyctinomops macrotis*
Mule Deer	*Odocoileus hemionus*
White-tailed Deer	*Odocoileus virginianus*
Northern Grasshopper Mouse	*Onychomys leucogaster*
Western Pipistrelle	*Pipistrellus hesperus*
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*
Desert Cottontail	*Sylvilagus audubonii*
Mexican free-tailed bat	*Tadarida brasiliensis mexicana*
American Badger	*Taxidea taxus*
Gray Fox	*Urocyon cinereoargenteus*
Kit Fox	*Vulpes macrotis*
Swift Fox	*Vulpes velox*
References:	
Amphibians and Reptiles	Collins and Taggart (2009)
Birds	AOU (1998)
Mammals	Frey *et al.* (2006)

Table 2. Dosimetric Factors for Avian, Mammal and Reptile Species and Calculation of Hydrogen Sulfide NOAEL, LOAEL and FEL for Wildlife.

Parameter	Equation	Black-chinned hummingbird[1]	Cassin's Sparrow	Mourning Dove	Scaled Quail	Greater Roadrunner	Chihuahuan Raven	Lesser Prairie-Chicken	Red-tailed Hawk
Mass (kg)		0.005	0.0255	0.115	0.177	0.3056	0.512	0.727	1.127
Resting Avian Respiration Rate (ml/min)	$V_{ER} = 385M^{0.72*}$	8.5	27.4	81.1	110.7	164.0	237.8	306.0	419.6
Resting Mammal Respiration Rate (ml/min)	$V_{ER} = 518M^{0.74*}$	—[a]	—	—	—	—	—	—	—
Resting Reptile Respiration Rate (ml/min)	$V_{ER} = 76.9M^{0.76**}$	—	—	—	—	—	—	—	—
Flying Avian Respiration Rate (ml/min)	$V_{EA} = 5000M^{0.74\dagger}$	99.1	331.0	1,009.0	1,388.3	2,079.6	3,046.7	3,949.2	5,462.5
Active Mammal Respiration Rate (ml/min)	—	—	—	—	—	—	—	—	—
Active Reptile Respiration Rate (ml/min)	$V_{EA} = 1922.5M^{0.76**}$	—	—	—	—	—	—	—	—
Trachea Length (cm²)	$Tl = 16.77M^{0.39\ddagger}$	2.1	4.0	7.2	8.5	10.6	12.9	14.8	17.6
Trachea Width (cm²)	$Td = 0.53M^{0.35\ddagger}$	0.08	0.15	0.25	0.29	0.35	0.42	0.47	0.55
Trachea Surface Area (cm²)	$SA_t = 2prh$	0.55	1.85	5.63	7.75	11.61	17.01	22.05	30.51
NOAEL Resting (mg/m³)	$= (190/15)/(V_{ER}/SA_t) \times 14$ mg/m³	11.6	12.0	12.3	12.4	12.6	12.7	12. 8	12.9
LOAEL Resting (mg/m³)	$= (190/15)/(V_{ER}/SA_t) \times 42$ mg/m³	34.7	35.9	37.0	37.3	37.7	38.1	38.3	38.7
FEL Resting (mg/m³)	$= (190/15)/(V_{ER}/SA_t) \times 100$ mg/m³	82.6	85.4	88.0	88.7	89.7	90.6	91.3	92.1
NOAEL Active (mg/m³)	$= (190/15)/(V_{EA}/SA_t) \times 14$ mg/m³	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
LOAEL Active (mg/m³)	$= (190/15)/(V_{EA}/SA_t) \times 42$ mg/m³	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97
FEL Active (mg/m³)	$= (190/15)/(V_{EA}/SA_t) \times 100$ mg/m³	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07
NOAEL Resting (ppm)	= NOAEL Resting (mg/m³)/1.39	8.3	8.6	8.9	8.9	9.0	9.1	9.2	9.3
LOAEL Resting (ppm)	= LOAEL Resting (mg/m³)/1.39	25.0	25.8	26.6	26.8	27.1	27.4	27.6	27.8
FEL Resting (ppm)	= FEL Resting (mg/m³)/1.39	59.4	61.4	63.3	63.8	64.5	65.2	65.7	66.2
NOAEL Active (ppm)	= NOAEL Active (mg/m³)/1.39	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LOAEL Active (ppm)	= LOAEL Active (mg/m³)/1.39	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
FEL Active (ppm)	= FEL Active (mg/m³)/1.39	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1

Table 2. Dosimetric Factors for Avian, Mammal and Reptile Species and Calculation of Hydrogen Sulfide NOAEL, LOAEL and FEL for Wildlife.

(~Continued) Parameter	Equation	Cave Myotis	Ord's Kangaroo Rat	Desert Cottontail	Kit Fox	Coyote	White-tailed Deer	Sand Dune Lizard
Mass (kg)		0.014	0.0834	0.756	1.82	10	50	0.0051
Resting Avian Respiration Rate (ml/min)	$V_{ER} = 385M^{0.72\,*}$	—	—	—	—	—	—	—
Resting Mammal Respiration Rate (ml/min)	$V_{ER} = 518M^{0.74\,*}$	22.0	82.4	421.1	806.8	2,846.6	9,366.3	—
Resting Reptile Respiration Rate (ml/min)	$V_{ER} = 76.9M^{0.76\,**}$	—	—	—	—	—	—	1.4
Flying Avian Respiration Rate (ml/min)	$V_{EA} = 5000M^{0.74\,\dagger}$	—	—	—	—	—	—	—
Active Mammal Respiration Rate (ml/min)	—	—	—	—	—	—	—	—
Active Reptile Respiration Rate (ml/min)	$V_{EA} = 1922.5M^{0.76\,**}$	—	—	—	—	—	—	34.8
Trachea Length (cm^2)	$Tl = 16.77M^{0.39\,\ddagger}$	1.1	2.3	5.5	7.9	15.6	29.6	—^{b}
Trachea Width (cm^2)	$Td = 0.53M^{0.35\,\ddagger}$	0.08	0.16	0.37	0.52	1.01	1.89	—^{b}
Trachea Surface Area (cm^2)	$SA_t = 2prh$	0.27	1.12	6.40	12.82	49.24	175.59	0.55^b
NOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x14\ mg/m^3$	2.21	2.41	2.70	2.82	3.07	3.32	70.52
LOAEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x42\ mg/m^3$	6.63	7.24	8.09	8.45	9.20	9.97	211.55
FEL Resting (mg/m^3)	$= (190/15)/(V_{ER}/SA_t)x100\ mg/m^3$	15.77	17.25	19.26	20.12	21.91	23.75	503.70
NOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x14\ mg/m^3$	—	—	—	—	—	—	2.82
LOAEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x42\ mg/m^3$	—	—	—	—	—	—	8.46
FEL Active (mg/m^3)	$= (190/15)/(V_{EA}/SA_t)x100\ mg/m^3$	—	—	—	—	—	—	20.15
NOAEL Resting (ppm)	= NOAEL Resting (mg/m^3)/1.39	1.6	1.7	1.9	2.0	2.2	2.4	50.7
LOAEL Resting (ppm)	= LOAEL Resting (mg/m^3)/1.39	4.8	5.2	5.8	6.1	6.6	7.2	152.2
FEL Resting (ppm)	= FEL Resting (mg/m^3)/1.39	11.3	12.4	13.9	14.5	15.8	17.1	362.4
NOAEL Active (ppm)	= NOAEL Active (mg/m^3)/1.39	—	—	—	—	—	—	2.0
LOAEL Active (ppm)	= LOAEL Active (mg/m^3)/1.39	—	—	—	—	—	—	6.1
FEL Active (ppm)	= FEL Active (mg/m^3)/1.39	—	—	—	—	—	—	14.5

* = Frappell *et al.* (2001)
† = Brown *et al.* (1997)
a = "—" = data not available
** = Bennett (1973)
‡ = Hinds and Calder (1971)
b = Assumed avian dimensions
= *Archilochus alexandrii* Example of high activity, small-bodied bird.

Table 3. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Winter Survey Season from November 21, 2002 to March 21, 2003.

Common Name	**Scientific Name**	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
American Kestrel	*Falco sparverius*	3	2	1.5	5.0
Bell's Vireo	*Vireo bellii*	1	1	0.5	2.5
Bewick's Wren	*Thryomanes bewickii*	3	0	1.5	0.0
Black Phoebe	*Sayornis nigricans*	1	0	0.5	0.0
Black-throated Sparrow	*Amphispiza bilineata*	14	1	7.1	2.5
Brewer's Blackbird	*Euphagus cyanocephalus*	9	1	4.6	2.5
Brown-headed Cowbird	*Molothrus ater*	2	0	1.0	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	2	0	1.0	0.0
Common Grackle	*Quiscalus quiscula*	5	4	2.5	10.0
Common Raven	*Corvus corax*	4	2	2.0	5.0
Crissal Thrasher	*Toxostoma crissale*	4	1	2.0	2.5
Curve-billed Thrasher	*Toxostoma curvirostre*	3	1	1.5	2.5
Dusky Flycatcher	*Empidonax oberholseri*	1	0	0.5	0.0
European Starling	*Sturnus vulgaris*	9	0	4.6	0.0
Gray Vireo	*Vireo vicinior*	7	0	3.5	0.0
Greater Roadrunner	*Geococcyx californianus*	2	0	1.0	0.0
House Sparrow	*Passer domesticus*	6	2	3.0	5.0
Lucy's Warbler	*Vermivora luciae*	1	1	0.5	2.5
Mourning Dove	*Zenaida macroura*	44	11	22.2	27.5
Northern Harrier	*Circus cyaneus*	2	0	1.0	0.0
Northern Mockingbird	*Mimus polyglottos*	4	1	2.0	2.5
Pyrrhuloxia	*Cardinalis sinuatus*	1	0	0.5	0.0
Red-tailed Hawk	*Buteo jamaicensis*	7	2	3.5	5.0
Say's Phoebe	*Sayornis saya*	2	0	1.0	0.0
Scaled Quail	*Callipepla squamata*	17	2	8.6	5.0
Virginia's Warbler	*Vermivora virginiae*	2	0	1.0	0.0
Varied Bunting	*Passerina versicolor*	2	2	1.0	5.0
Western Meadow Lark	*Sturnella neglecta*	2	2	1.0	5.0
Western Scrub-Jay	*Aphelocoma californica*	2	0	1.0	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	18	1	9.1	2.5
White-winged Dove	*Zenaida asiatica*	12	2	6.1	5.0
Yellow-billed Cuckoo	*Coccyzus americanus*	3	0	1.5	0.0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2	0	1.0	0.0
Yellow-rumped Warbler	*Dendroica coronata*	1	1	0.5	2.5

Table 4. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Spring Survey Season from March 21, 2003 to June 21, 2003.

Common Name	**Scientific Name**	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
Black-throated Sparrow	*Amphispiza bilineata*	2	1	3.2	16.7
Brewer's Blackbird	*Euphagus cyanocephalus*	1	0	1.6	0.0
Brown-headed Cowbird	*Molothrus ater,*	2	0	3.2	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	1	0	1.6	0.0
Common Raven	*Corvus corax*	1	0	1.6	0.0
Curve-billed Thrasher	*Toxostoma curvirostre*	3	0	4.8	0.0
Dusky Flycatcher	*Empidonax oberholseri*	5	0	8.1	0.0
Greater Roadrunner	*Geococcyx californianus*	2	0	3.2	0.0
Mourning Dove	*Zenaida macroura*	6	3	9.7	50.0
Northern Mockingbird	*Mimus polyglottos*	6	0	9.7	0.0
Scaled Quail	*Callipepla squamata*	13	1	21.0	16.7
Scissor-tailed Flycatcher	*Tyrannus forficatus*	3	0	4.8	0.0
Vermillion Flycatcher	*Pyrocephalus rubinus*	1	0	1.6	0.0
Western Meadowlark	*Sturnella neglecta*	6	0	9.7	0.0
Western Scrub-Jay	*Aphelocoma californica*	3	1	4.8	16.7
Western Wood-Peewee	*Contopus sordidulus*	1	0	1.6	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	6	0	9.7	0.0

Table 5. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Summer Survey Season from June 21, 2003 to August 6, 2003.

Common Name	***Scientific Name***	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
Black Phoebe	*Sayornis nigricans*	1	0	1.9	0.0
Black-throated Sparrow	*Amphispiza bilineata*	3	0	5.6	0.0
Common Nighthawk	*Chordeiles minor*	1	2	1.9	13.3
Common Raven	*Corvus corax*	3	0	5.6	0.0
Crissal Thrasher	*Toxostoma crissale*	1	0	1.9	0.0
Dusky Flycatcher	*Empidonax oberholseri*	1	1	1.9	6.7
Greater Roadrunner	*Geococcyx californianus*	1	1	1.9	6.7
Horned Lark	*Eremophila alpestris*	0	7	0.0	46.7
Mourning Dove	*Zenaida macroura*	15	0	27.8	0.0
Northern Mockingbird	*Mimus polyglottos*	1	0	1.9	0.0
Red-tailed Hawk	*Buteo jamaicensis*	1	0	1.9	0.0
Scaled Quail	*Callipepla squamata*	19	0	35.2	0.0
Vermillion Flycatcher	*Pyrocephalus rubinus*	1	0	1.9	0.0
Western Kingbird	*Tyrannus verticalis*	1	4	1.9	26.7
Western Meadowlark	*Sturnella neglecta*	2	0	3.7	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	3	0	5.6	0.0

Table 6. Species Composition of Birds Present at the Disturbed Sites and Undisturbed Sites During the Overall Study from November 21, 2002 to August 6, 2003.

Common Name	***Scientific Name***	**Total No. Undisturbed Sites**	**Total No. Disturbed Sites**	**Percent Undisturbed Sites**	**Percent Disturbed Sites**
American Kestrel	*Falco sparverius*	3	2	1.0	3.5
Bell's Vireo	*Vireo bellii*	1	1	0.3	1.7
Bewick's Wren	*Thryomanes bewickii*	4	0	1.3	0.0
Black Phoebe	*Sayornis nigricans*	2	0	0.6	0.0
Black-throated Sparrow	*Amphispiza bilineata*	19	2	6.1	3.5
Brewer's Blackbird	*Euphagus cyanocephalus*	10	1	3.2	1.7
Brown-headed Cowbird	*Molothrus ater*	4	0	1.3	0.0
Cactus Wren	*Campylorhychus brunneicapillus*	3	0	1.0	0.0
Common Grackle	*Quiscalus quiscula*	5	4	1.6	6.9
Common Nighthawk	*Chordeiles minor*	1	2	0.3	3.5
Common Raven	*Corvus corax*	8	2	2.6	3.5
Crissal Thrasher	*Toxostoma crissale*	5	1	1.6	1.7
Curve-billed Thrasher	*Toxostoma curvirostre*	6	1	1.9	1.7
Dusky Flycatcher	*Empidonax oberholseri*	7	1	2.2	1.7
European Starling	*Sturnus vulgaris*	9	0	2.9	0.0
Gray Vireo	*Vireo vicinior*	7	0	2.2	0.0
Greater Roadrunner	*Geococcyx californianus*	5	1	1.6	1.7
Horned Lark	*Eremophila alpestris*	0	6	0.0	10.3
House Sparrow	*Passer domesticus*	6	2	1.9	3.5
Lucy's Warbler	*Vermivora luciae*	1	1	0.3	1.7
Mourning Dove	*Zenaida macroura*	65	14	20.7	24.1
Northern Harrier	*Circus cyaneus*	2	0	0.6	0.0
Northern Mockingbird	*Mimus polyglottos*	11	1	3.5	1.7
Pyrrhuloxia	*Cardinalis sinuatus*	1	0	0.3	0.0
Red-tailed Hawk	*Buteo jamaicensis*	8	2	2.6	3.5
Say's Phoebe	*Sayornis saya*	2	0	0.6	0.0
Scaled Quail	*Callipepla squamata*	48	3	15.3	5.2
Scissor-tailed Flycatcher	*Tyrannus forficatus*	3	0	1.0	0.0
Virginia's Warbler	*Vermivora virginiae*	2	0	0.6	0.0
Varied Bunting	*Passerina versicolor*	2	2	0.6	3.5
Vermillion Flycatcher	*Pyrocephalus rubinus*	2	0	0.6	0.0
Western Kingbird	*Tyrannus verticalis*	1	2	0.3	3.5
Western Meadowlark	*Sturnella neglecta*	10	2	3.2	3.5
Western Scrub-Jay	*Aphelocoma californica*	5	1	1.6	1.7
Western Wood-Peewee	*Contopus sordidulus*	1	0	0.3	0.0
White-crowned Sparrow	*Zonotrichia leucophrys*	27	1	8.6	1.7
White-winged Dove	*Zenaida asiatica*	12	2	3.8	3.5
Yellow-billed Cuckoo	*Coccyzus americanus*	3	0	1.0	0.0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2	0	0.6	0.0
Yellow-rumped Warbler	*Dendroica coronata*	1	1	0.3	1.7

Appendix A-1. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
1	11/21/2002	32.786633	-104.202917	11	4	0
2	11/21/2002	32.776650	-104.204367	6	2	0
3	11/21/2002	32.730000	-104.211350	2	1	0
4	11/21/2002	32.718733	-104.212217	1	1	0
5	11/21/2002	32.706300	-104.212883	0	0	0
6	11/21/2002	32.657883	-104.222150	5	2	0
7	11/21/2002	32.636983	-104.224633	3	1	1
8	11/21/2002	32.626567	-104.224900	0	0	0
9	11/21/2002	32.581250	-104.225600	7	3	1
10	11/21/2002	32.568450	-104.225833	0	0	0
11	12/3/2002	32.691767	-103.892217	11	3	0
12	12/3/2002	32.689083	-103.902900	8	3	0
13	12/3/2002	32.688883	-103.916817	4	2	0
14	12/3/2002	32.688983	-103.929200	0	0	0
15	12/3/2002	32.663650	-103.991867	8	3	0
16	12/3/2002	32.660183	-104.003967	1	1	0
17	12/3/2002	32.637833	-104.021017	0	0	0
18	12/3/2002	32.634167	-104.029983	3	1	0
19	12/3/2002	32.656133	-104.088433	15	3	0
20	12/3/2002	32.658550	-104.106550	3	1	1
21	1/7/2003	32.780367	-103.766800	1	1	0
22	1/7/2003	32.774683	-103.774583	0	0	0
23	1/7/2003	32.768683	-103.780483	5	2	0
24	1/7/2003	32.712483	-103.796767	6	2	0
25	1/7/2003	32.704483	-103.796767	3	1	0
26	1/7/2003	32.695167	-103.796767	15	3	0
27	1/7/2003	32.684967	-103.796767	1	1	0
28	1/7/2003	32.672183	-103.796767	5	2	0
29	1/7/2003	32.657600	-103.766800	12	3	0
30	1/7/2003	32.658367	-103.753933	7	2	1
31	1/23/2003	32.827833	-103.529417	11	4	0
32	1/23/2003	32.827833	-103.539967	3	1	0
33	1/23/2003	32.827833	-103.551867	15	3	0
34	1/23/2003	32.827833	-103.562183	4	2	0
35	1/23/2003	32.804067	-103.628617	3	1	0
36	1/23/2003	32.802083	-103.639867	2	1	0

Appendix A-1 *Continued*. Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H2S Concentration (ppm)
37	1/23/2003	32.804450	-103.649067	8	2	0
38	1/23/2003	32.801550	-103.677700	3	1	0
39	1/23/2003	32.802117	-103.687767	2	1	0
40	1/23/2003	32.811700	-103.701667	0	0	0
41	2/11/2003	32.782400	-104.019633	0	0	0
42	2/11/2003	32.773817	-104.019600	0	0	0
43	2/11/2003	32.756000	-104.017717	0	0	0
44	2/11/2003	32.747750	-104.017967	0	0	0
45	2/11/2003	32.830567	-103.978967	0	0	0
46	2/11/2003	32.839867	-103.977467	0	0	0
47	2/11/2003	32.859983	-103.977433	1	1	0
48	2/11/2003	32.872450	-103.964517	1	1	0
49	3/4/2003	32.896367	-104.036683	1	1	0
50	3/4/2003	32.886950	-104.036667	0	0	0
51	3/4/2003	32.839600	-104.037033	1	1	1
52	3/4/2003	32.847250	-104.071733	0	0	1
53	4/3/2003	32.856100	-104.037383	1	1	1
54	4/3/2003	32.856150	-104.048950	0	0	0
55	4/3/2003	32.872283	-104.021233	1	1	0
56	4/3/2003	32.872417	-104.994433	0	0	0
57	4/3/2003	32.880700	-104.981017	4	1	0
58	4/3/2003	32.914017	-103.962900	0	0	0
59	4/3/2003	32.913983	-103.932733	0	0	0
60	4/3/2003	32.911867	-103.922917	2	1	0
61	4/3/2003	32.899533	-103.924067	1	1	0
62	4/9/2003	32.889567	-103.926200	0	0	0
63	4/9/2003	32.838600	-103.930933	3	2	0
64	4/9/2003	32.800183	-103.939517	1	1	0
65	4/9/2003	32.859133	-103.926717	0	0	0
66	4/9/2003	32.854267	-103.908583	6	1	0
67	4/9/2003	32.846850	-103.908267	1	1	0
68	4/16/2003	32.801867	-104.019650	3	2	0
69	4/16/2003	32.780200	-104.019617	4	2	0
70	4/16/2003	32.770700	-104.019667	1	1	0
71	4/16/2003	32.751767	-104.017233	2	2	0
72	4/16/2003	32.755667	-104.007667	1	1	0

Appendix A-1 *Continued.* Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
73	4/16/2003	32.721983	-103.997967	1	1	0
74	4/16/2003	32.753467	-103.988167	0	0	0
75	4/16/2003	32.759850	-103.984483	0	0	0
76	4/16/2003	32.768533	-103.984400	1	1	0
77	4/16/2003	32.776867	-103.984267	2	2	0
78	4/16/2003	32.782650	-103.992433	0	0	0
79	4/16/2003	32.782950	-104.001933	3	1	0
80	4/16/2003	32.783017	-104.011900	3	2	0
81	4/24/2003	33.038650	-103.985467	2	1	0
82	4/24/2003	33.030150	-103.985350	3	1	0
83	4/24/2003	33.020867	-103.918883	0	0	0
84	4/24/2003	32.993967	-103.985550	2	1	0
85	4/24/2003	32.967017	-103.985450	2	1	0
86	4/24/2003	32.974333	-103.985467	3	2	2
87	4/24/2003	32.965367	-103.985450	0	0	1
88	4/24/2003	32.956050	-103.985400	1	1	1
89	4/24/2003	32.954217	-103.948700	2	1	1
90	4/24/2003	32.955817	-103.943967	1	1	1
91	4/24/2003	32.964100	-103.934083	2	1	1
92	4/24/2003	32.952967	-103.925067	1	1	0
93	4/24/2003	32.952900	-103.913533	1	1	0
94	4/24/2003	32.948600	-103.887267	1	1	0
95	6/28/2003	32.756450	-103.883250	3	1	0
96	6/28/2003	32.754083	-103.880983	4	2	0
97	6/28/2003	32.749767	-103.871883	1	1	0
98	6/28/2003	32.745833	-103.866100	1	1	1
99	6/28/2003	32.741583	-103.860633	2	1	0
100	6/28/2003	32.737000	-103.855850	2	1	0
101	6/28/2003	32.757617	-103.756450	2	1	0
102	6/28/2003	32.746933	-103.756450	3	1	0
103	6/28/2003	32.739867	-103.749300	0	0	0
104	6/28/2003	32.734917	-103.756250	1	1	0
105	7/17/2003	32.809150	-103.758733	2	1	1
106	7/17/2003	32.838833	-103.924750	11	1	1
107	7/17/2003	32.861783	-103.924750	0	0	1
108	7/17/2003	32.868283	-103.930250	0	0	1

Appendix A-1 *Continued.* Data Set for **Undisturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
109	8/6/2003	32.769733	-103.606817	4	1	0
110	8/6/2003	32.775933	-103.604083	2	1	0
111	8/6/2003	32.794450	-103.595967	5	1	0
112	8/6/2003	32.800617	-103.586667	0	0	0
113	8/6/2003	32.806783	-103.579250	3	1	0
114	8/6/2003	32.813017	-103.573883	1	1	0
115	8/6/2003	32.824550	-103.566233	0	0	0
116	8/6/2003	32.730467	-103.603933	2	1	0
117	8/6/2003	32.712817	-103.594167	2	2	1
118	8/6/2003	32.707167	-103.588467	1	1	0
119	8/6/2003	32.703033	-103.605350	2	1	1
120	8/6/2003	32.696750	-103.600883	0	0	0

Appendix A-2. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
1	11/21/2002	32.764950	-104.207317	2	1	1
2	11/21/2002	32.753683	-104.209450	0	0	1
3	11/21/2002	32.741717	-104.210450	0	0	1
4	11/21/2002	32.695083	-104.213800	0	0	1
5	11/21/2002	32.682267	-104.214250	3	2	1
6	11/21/2002	32.670817	-104.219483	1	1	2
7	11/21/2002	32.646967	-104.223650	1	1	2
8	11/21/2002	32.615283	-104.225183	4	2	2
9	11/21/2002	32.605017	-104.225917	0	0	1
10	11/21/2002	32.592950	-104.225383	0	0	1
11	12/3/2002	32.693867	-103.941650	0	0	1
12	12/3/2002	32.697467	-103.949500	2	1	1
13	12/3/2002	32.686917	-103.956583	1	1	2
14	12/3/2002	32.678967	-103.967950	1	1	2
15	12/3/2002	32.671317	-103.982783	1	1	2
16	12/3/2002	32.657633	-104.017700	0	0	2
17	12/3/2002	32.647167	-104.021617	0	0	1
18	12/3/2002	32.640000	-104.042883	2	2	2
19	12/3/2002	32.645200	-104.055767	0	0	1
20	12/3/2002	32.650883	-104.069900	0	0	2
21	1/7/2003	32.758133	-103.780633	0	0	3
22	1/7/2003	32.750250	-103.786133	2	1	1
23	1/7/2003	32.744567	-103.792800	0	0	1
24	1/7/2003	32.735500	-103.795700	2	1	1
25	1/7/2003	32.725517	-10.795517	4	2	1
26	1/7/2003	32.661983	-103.796633	0	0	1
27	1/7/2003	32.653433	-103.796417	2	1	1
28	1/7/2003	32.644850	-103.796417	3	3	2
29	1/7/2003	32.634467	-103.798033	0	0	2
30	1/7/2003	32.656950	-103.777617	0	0	2
31	1/23/2003	32.827050	-103.575317	0	0	2
32	1/23/2003	32.822850	-103.585217	2	1	1
33	1/23/2003	32.819467	-103.593400	0	0	1
34	1/23/2003	32.815533	-103.602667	0	0	1
35	1/23/2003	32.811417	-103.611967	1	1	1
36	1/23/2003	32.807950	-103.619833	2	1	3

Appendix A-2 *Continued.* Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
37	1/23/2003	32.806183	-103.658583	0	0	3
38	1/23/2003	32.804483	-103.667683	0	0	3
39	1/23/2003	32.807917	-103.693767	0	0	3
40	1/23/2003	32.818217	-103.711617	0	0	1
41	2/11/2003	32.810133	-104.019617	0	0	2
42	2/11/2003	32.800667	-104.019600	1	1	1
43	2/11/2003	32.792883	-104.021250	0	0	1
44	2/11/2003	32.764050	-104.019683	0	0	2
45	2/11/2003	32.850583	-103.978550	0	0	1
46	2/11/2003	32.867450	-103.972183	0	0	2
47	3/4/2003	32.875383	-104.043667	0	0	1
48	3/4/2003	32.848500	-104.037350	0	0	2
49	3/4/2003	32.832933	-104.037400	0	0	1
50	3/4/2003	32.823550	-104.037033	0	0	1
51	4/3/2003	32.872450	-104.034383	1	1	1
52	4/3/2003	32.872467	-104.009517	0	0	1
53	4/3/2003	32.872533	-103.983300	0	0	1
54	4/3/2003	32.873650	-103.969367	0	0	1
55	4/3/2003	32.872533	-103.957483	0	0	1
56	4/3/2003	32.872667	-103.946267	0	0	2
57	4/3/2003	32.914833	-103.945083	0	0	2
58	4/9/2003	32.881733	-103.926417	0	0	2
59	4/9/2003	32.872383	-103.927750	0	0	1
60	4/9/2003	32.865400	-103.927617	0	0	1
61	4/9/2003	32.854517	-103.927517	0	0	1
62	4/9/2003	32.847100	-103.927483	0	0	2
63	4/9/2003	32.830867	-103.933950	0	0	1
64	4/9/2003	32.821333	-103.936317	0	0	2
65	4/9/2003	32.813483	-103.937267	0	0	1
66	4/9/2003	32.803817	-103.936150	0	0	2
67	4/9/2003	32.828783	-103.908117	0	0	1
68	4/9/2003	32.838783	-103.914733	1	1	2
69	4/9/2003	32.838167	-103.920983	0	0	1
70	4/9/2003	32.872467	-103.921067	0	0	2
71	4/9/2003	32.867317	-103.913350	0	0	1
72	4/16/2003	32.791767	-104.020750	0	0	1

Appendix A-2 *Continued.* Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
73	4/16/2003	32.761717	-104.019683	0	0	1
74	4/16/2003	32.746650	-104.017767	0	0	1
75	4/16/2003	32.791450	-104.012367	0	0	1
76	4/24/2003	33.003033	-103.983583	0	0	0
77	4/24/2003	32.947183	-103.981417	0	0	1
78	4/24/2003	32.961517	-103.981417	0	0	1
79	4/24/2003	32.956083	-103.966533	0	0	0
80	4/24/2003	32.955900	-103.958017	0	0	0
81	4/24/2003	32.949067	-103.902983	2	1	1
82	4/24/2003	32.945433	-103.898150	1	1	1
83	4/24/2003	32.951300	-103.879083	1	1	1
84	6/28/2003	32.751867	-103.885683	0	0	3
85	6/28/2003	32.762617	-103.887550	0	0	3
86	6/28/2003	32.752667	-103.877017	3	1	3
87	6/28/2003	32.752867	-103.885150	1	1	2
88	6/28/2003	32.742833	-103.886117	0	0	4
89	6/28/2003	32.735317	-103.888650	0	0	4
90	6/28/2003	32.720233	-103.885083	2	1	4
91	6/28/2003	32.767233	-103.776883	1	1	3
92	6/28/2003	32.770883	-103.769367	0	0	2
93	6/28/2003	32.770767	-103.756600	0	0	2
94	6/28/2003	32.770867	-103.747717	0	0	1
95	6/28/2003	32.764733	-103.760850	0	0	1
96	6/28/2003	32.750450	-103.765450	0	0	4
97	6/28/2003	32.730467	-103.757867	0	0	7
98	6/28/2003	32.727433	-103.768150	2	1	3
99	7/17/2003	32.809150	-103.762467	2	2	0
100	7/17/2003	32.809200	-103.754283	0	0	1
101	7/17/2003	32.800150	-103.752267	0	0	1
102	7/17/2003	32.816133	-103.870250	0	0	1
103	7/17/2003	32.826000	-103.876250	0	0	1
104	7/17/2003	32.829283	-103.879983	1	1	1
105	7/17/2003	32.821733	-103.878100	1	1	1
106	7/17/2003	32.815967	-103.906583	0	0	0
107	7/17/2003	32.838883	-103.914350	0	0	0
108	7/17/2003	32.847267	-103.927400	0	0	0

Appendix A-2 *Continued*. Data Set for **Disturbed Sites** Including Survey Number, Date, Latitude, Longitude, Total Number of Birds, Number of Species, H_2S Concentration for Each Survey.

Survey No.	Date	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Total No. of Birds	Number of Species	H_2S Concentration (ppm)
109	7/17/2003	32.859867	-103.921233	0	0	0
110	8/6/2003	32.760433	-103.606817	1	1	2
111	8/6/2003	32.744950	-103.609067	0	0	1
112	8/6/2003	32.734833	-103.609983	0	0	3
113	8/6/2003	32.727033	-103.597567	0	0	3
114	8/6/2003	32.716683	-103.597383	1	1	1
115	8/6/2003	32.716833	-103.602033	0	0	4
116	8/6/2003	32.712867	-103.609950	0	0	1

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
1								
2	1							
3								2
4				1				
5								
6					1			
7						3		
8								
9					3			
10								
11					5			
12								
13								
14								
15						2		
16								
17								
18								
19								
20								
21			3					
22								
23								
24								
25								
26								
27	1							
28		1						
29					5			
30								
31	1							
32								
33						4	2	
34								
35								
36								
37								
38								
39								
40			1					
41								
42								
43								
44								

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
45								
46								
47								
48								
49								
50								
51								
52								
53								1
54								
55								
56								
57								
58								
59								
60							2	
61								
62								
63								
64								
65								
66								
67								
68						1		
69								
70								
71								
72								
73								
74								
75								
76								
77								
78								
79								
80								
81								
82								
83								
84								
85					2			
86								
87								
88								

Appendix B. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
89								
90								
91								
92								
93								
94								
95								
96				1				
97								
98								
99								
100								
101								
102								
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113					3			
114								
115								
116								
117								
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	*Common* Grackle	*Common* Nighthawk	*Common* Raven	*Crissal* Thrasher	*Curve-billed* Thrasher	*Dusky* Flycatcher	*European* Starling	Gray Vireo
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12						1		
13								
14								
15	5							
16								
17								
18								
19								
20								
21								
22			4					
23								
24								
25					3			
26								
27								
28								
29								
30				4				
31								
32								
33							9	
34								7
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61					1			
62								
63								
64								
65								
66								
67								
68								
69						1		
70								
71								
72								
73								
74								
75								
76								
77					1			
78								
79								
80								
81						2		
82								
83								
84								
85								
86			1			2		
87								
88								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
89								
90					1			
91								
92								
93								
94								
95								
96								
97		1						
98								
99								
100								
101								
102								
103								
104								
105								
106						1		
107								
108								
109			2					
110								
111								
112								
113								
114			1					
115								
116								
117				1				
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
1	1				6			
2					5			
3								
4								
5								
6								
7								
8								
9							1	
10								
11							2	
12					6	1		
13								
14								
15			1					
16								1
17								
18								
19								
20					3			
21								
22								
23								
24								
25								
26					13		1	
27								
28								
29			5					
30								
31				1	7			
32					3			
33								
34								
35	1							
36								
37						1		
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater *Roadrunner*	Horned *Lark*	House *Sparrow*	Lucy's *Warbler*	Mourning *Dove*	Northern *Harrier*	Northern *Mockingbird*	*Pyrrhuloxia*
45								
46								
47					1			
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64	1							
65								
66								
67					1			
68								
69								
70								
71					1			
72							1	
73								
74								
75								
76								
77								
78								
79								
80					2			
81								
82								
83								
84					2			
85								
86								
87								
88							2	

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
89							1	
90								
91							2	
92								
93								
94	1							
95					3			
96					3			
97								
98								
99					2			
100					1			
101								
102								
103								
104	1							
105					2			
106								
107								
108								
109								
110							1	
111								
112								
113								
114								
115								
116					2			
117					1			
118					1			
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
1	1		3					
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19	1							
20			1					
21		2						
22								
23								
24								
25								
26								
27								
28			4					
29					2			
30	3							
31						2		
32								
33								
34								
35								
36	2							
37			7					
38								
39								
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
45								
46								
47								
48			1					
49								
50								
51			1					
52								
53								
54								
55							1	
56								
57			4					
58								
59								
60								
61								
62								
63								
64								
65								
66			6					
67								
68			2					
69								
70								
71								
72								
73			1					
74								
75								
76								
77								
78								
79								
80								
81								
82				3				
83								
84								
85								
86								
87								
88								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
89								
90								
91								
92								
93								
94								
95								
96								
97								
98	1							
99								
100								
101			2					
102								
103								
104								
105								1
106			11					
107								
108								
109								
110								
111			5					
112							1	
113								
114								
115								
116								
117								
118								
119								
120								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
1								
2								
3								
4								
5								
6						1		
7								
8								
9				3				
10								
11				4				
12								
13							2	1
14								
15								
16								
17								
18				3				
19	2				12			
20								
21								
22		2						
23								
24								
25								
26				1				
27								
28								
29								
30								
31								
32								
33								
34				3				
35								
36								
37								
38				3				
39						2		
40								
41								
42								
43								
44								

Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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80		1						
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Appendix B. Continued. Data Set for Undisturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Dove	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
89								
90								
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92		1						
93	1							
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120								

Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	American Kestrel	Bell's Vireo	Bewick's Wren	Black Phoebe	Black-throated Sparrow	Brewer's Blackbird	Brown-headed Cowbird	Cactus Wren
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Common Grackle	Common Nighthawk	Common Raven	Crissal Thrasher	Curve-billed Thrasher	Dusky Flycatcher	European Starling	Gray Vireo
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Greater Roadrunner	Horned Lark	House Sparrow	Lucy's Warbler	Mourning Dove	Northern Harrier	Northern Mockingbird	Pyrrhuloxia
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Red-tailed Hawk	Say's Phoebe	Scaled Quail	Scissor-tailed Flycatcher	Virginia's Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	*Red-tailed* Hawk	*Say's* Phoebe	Scaled Quail	Scissor-*tailed* Flycatcher	*Virginia's* Warbler	Varied Bunting	Vermillion Flycatcher	Western Kingbird
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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Appendix C. Continued. Data Set for Disturbed Sites Including Survey Number and Species Composition for Each Survey.

Survey No.	Western Meadowlark	Western Scrub-Jay	Western Wood-Peewee	White-crowned Sparrow	White-winged Doved	Yellow-billed Cuckoo	Yellow-headed Blackbird	Yellow-rumped Warbler
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Geochemistry of formation waters from the Wolfcamp and "Cline" shales: Insights into brine origin, reservoir connectivity, and fluid flow in the Permian Basin, USA

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ABSTRACT

Despite being one of the most important oil producing provinces in the United States, information on basinal hydrogeology and fluid flow in the Permian Basin of Texas and New Mexico is lacking. The source and geochemistry of brines from the basin were investigated (Ordovician- to Guadalupian-age reservoirs) by combining previously published data from conventional reservoirs with geochemical results for 39 new produced water samples, with a focus on those from shales. Salinity of the Ca–Cl-type brines in the basin generally increases with depth reaching a maximum in Devonian (median = 154 g/L) reservoirs, followed by decreases in salinity in the Silurian (median = 77 g/L) and Ordovician (median = 70 g/L) reservoirs. Isotopic data for B, O, H, and Sr and ion chemistry indicate three major types of water. Lower salinity fluids (<70 g/L) of meteoric origin in the middle and upper Permian hydrocarbon reservoirs (1.2–2.5 km depth; Guadalupian and Leonardian age) likely represent meteoric waters that infiltrated through and dissolved halite and anhydrite in the overlying evaporite layer. Saline (>100 g/L), isotopically heavy (O and H) water in Leonardian [Permian] to Pennsylvanian reservoirs (2–3.2 km depth) is evaporated, Late Permian seawater. Water from the Permian Wolfcamp and Pennsylvanian "Cline" shales, which are isotopically similar but lower in salinity and enriched in alkalis, appear to have developed their composition due to post-illitization diffusion into the shales. Samples from the "Cline" shale are further enriched with NH_4, Br, I and isotopically light B, sourced from the breakdown of marine kerogen in the unit. Lower salinity waters (<100 g/L) in Devonian and deeper reservoirs (>3 km depth), which plot near the modern local meteoric water line, are distinct from the water in overlying reservoirs. We propose that these deep meteoric waters are part of a newly identified hydrogeologic unit: the Deep Basin Meteoric Aquifer System. Chemical, isotopic, and pressure data suggest that despite over-pressuring in the Wolfcamp shale, there is little potential for vertical fluid migration to the surface environment via natural conduits.

1. Introduction

The Permian Basin of Texas and New Mexico is the most productive tight oil province in the United States, which at the time of writing this paper generates more than 2 million barrels of oil per day (U.S. Energy Information Administration, 2016). Geologic studies of the basin are numerous, given its long history in oil and gas production (Frenzel et al., 1988; Galley, 1958; Ward et al., 1986), and recent efforts have been initiated to better understand the nature of the source rocks (Cortez, 2012; Hamlin and Baumgardner, 2012; Sinclair, 2007). Despite the hundreds of geologic and petroleum resource investigations completed over the last ~80 years, studies of formation brines from the basin are sparse and primarily focused along the northern tier of the Permian Basin (Dutton, 1987; Eastoe et al., 1999; Herczeg et al., 1988; Lambert, 1992; Stein and Krumhansl, 1988), in an effort to investigate fluid movement near potential nuclear waste storage sites. The lack of investigation of formation brines in the basin is at least partly due to the long history and wide-spread use of water-flooding and CO_2 injection for enhanced recovery (Melzer, 2013), which can impact the chemistry and interpretation of formation waters (Engle and Blondes, 2014). Chemical data for produced water from recently developed mudrock and shale reservoirs in the Permian Basin are absent from published literature.

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Given concerns over potential impacts from unconventional oil and gas development, ranging from toxicological effects from exposure to accidental releases of produced fluids into the environment to potential migration of injected fluids into shallow groundwater system (Vengosh et al., 2014; Vidic et al., 2013), understanding the composition of produced waters from shale reservoirs is critical (Chapman et al., 2012; Rowan et al., 2015). Moreover, investigations of reservoir pressure data (Luo et al., 1994), an important proxy for potential vertical fluid migration, are scarce and spatially limited to small areas of Delaware Basin, a sub-basin of the Permian (Fig. 1).

To provide a better hydrogeologic understanding of the Permian Basin, particularly the origin, nature, and potential flowpaths of fluids from shale reservoirs, this paper investigates the geochemistry of formation brines, with particular focus on $\delta^{18}O$, $\delta^{2}H$, $^{87}Sr/^{86}Sr$ and $\delta^{11}B$ data, from two of the most productive shale reservoirs of the basin, the Wolfcamp and "Cline" shales, as well as adjacent reservoirs. To better

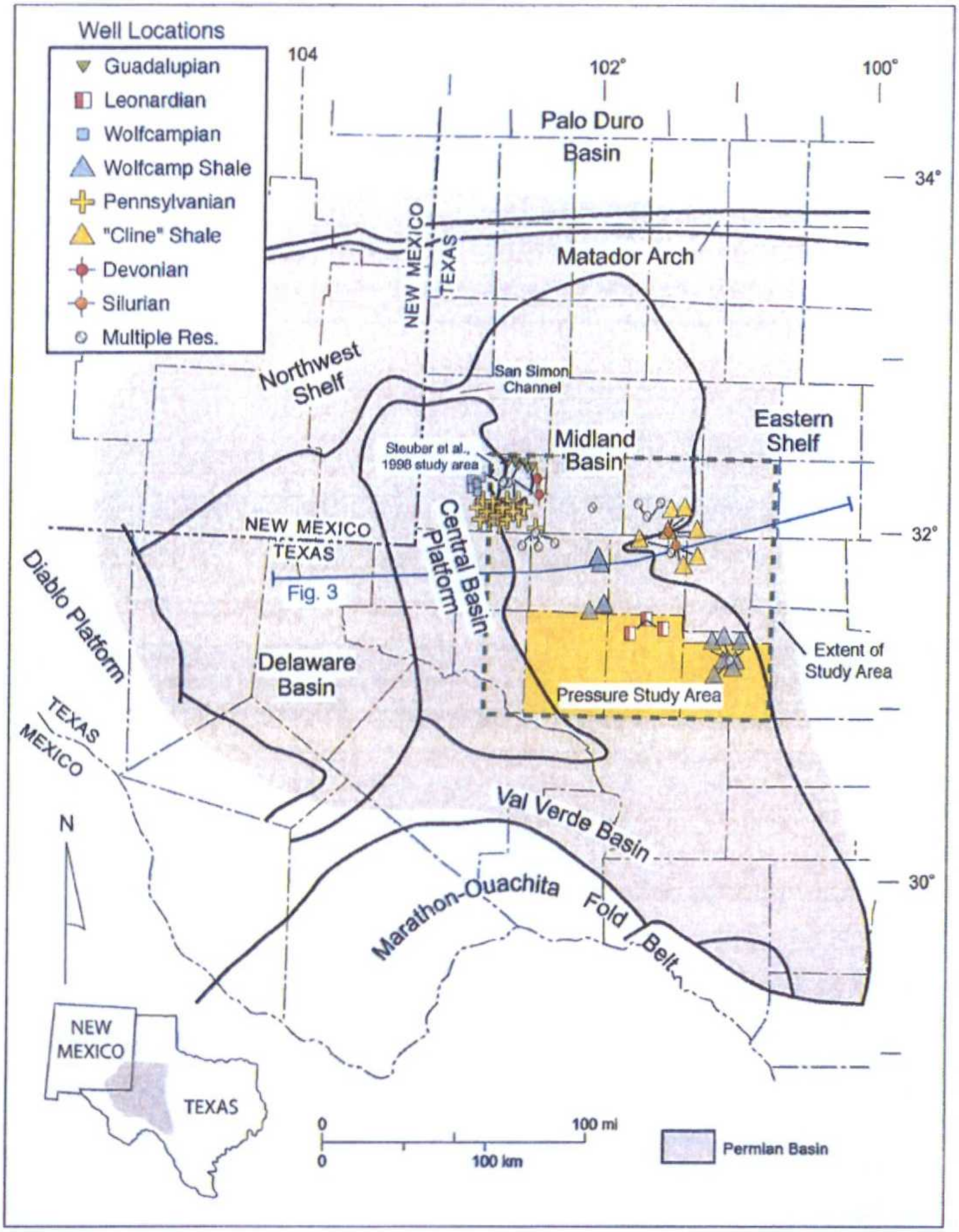


Fig. 1. Map of the Permian Basin showing major basin structures, the extent of the study area, locations of samples containing isotopic data, and the pressure study area. Well locations offset to minimize symbol overlap. Blue line shows the approximate locations of the geologic cross-section in Fig. 3. Base map modified from Dutton et al. (2005). Multiple Res. = well producing from multiple reservoirs.

represent the chemistry of natural formation waters, rather than fluids injected for fracture stimulation, the study utilizes data from wells which have been in production for months or years, such that most of the injected fluid has been removed during production or imbibed into the reservoir (Rowan et al., 2015). A subset of the samples from the Wolfcamp and "Cline" shales, collected as part of this investigation, were analyzed for organic compounds and are discussed elsewhere (Khan et al., 2016). Additional focus in this study is given to reservoir pressure data through the Paleozoic section at the center of the Midland Basin (Fig. 2) as a means to examine vertical fluid flow potential. Linked reservoir pressure and geochemical data are useful for both understanding potential for environmental impacts from development of tight oil reservoirs as well as placing constraints on basinal hydrogeology and the history of fluid flow.

2. Geology and produced waters of the Permian Basin

The present-day Permian Basin covers an area of roughly 190,000 km^2 and comprises two sub-basins, the Delaware Basin to the west and the Midland Basin to the east, separated by the Central Basin Platform (Fig. 1). It was preceded by the Tobosa Basin (Fig. 3), an interior subsidence basin in a passive margin setting which existed from the Precambrian into the early Mississippian (Frenzel et al., 1988). Lithologically, strata deposited during that period consist of shallow-water carbonates and sandstones capped with the organic-rich Woodford Shale in the Late Devonian. Collision of North America and South America, starting in the Late Mississippian and Early Pennsylvanian, led to differential subsidence behind the southwest–northeast trending Marathon–Ouachita fold belt, creating the primary features of the Permian Basin (Fig. 3), including the Delaware Basin, the Midland Basins and the Central Basin Platform (Miall, 2008). During the Pennsylvanian and Early Permian, carbonates were deposited onto the shelves (e.g., Northwest Shelf, Eastern Shelf, and Central Basin Platform) with fine-grained materials settling in the basin centers. Starting in the Late Guadalupian, there was a transition to redbed sandstone deposition and eventually evaporite formation into the Ochoan, including halite and anhydrite, on the Central Basin Platform, Northwest Shelf, Eastern Shelf and within the Midland Basin (Ward et al., 1986). Thus the sequence of Permian-age rocks in the basin, which exceeds 3000 m in areas (Fig. 4), transitions from carbonates and shale to siliciclastic sandstones and finally evaporite sequences. During the Triassic, the region shifted to a closed continental basin, receiving fluvial and lacustrine sediments, laying down a relatively thin layer of siliciclastics.

Several source rocks are present in the Permian Basin, including the Woodford, Barnett, Wolfcamp, "Cline", Dean, and Spraberry units (Fig. 2). The organic- and clay-rich layers within the Upper Pennsylvanian

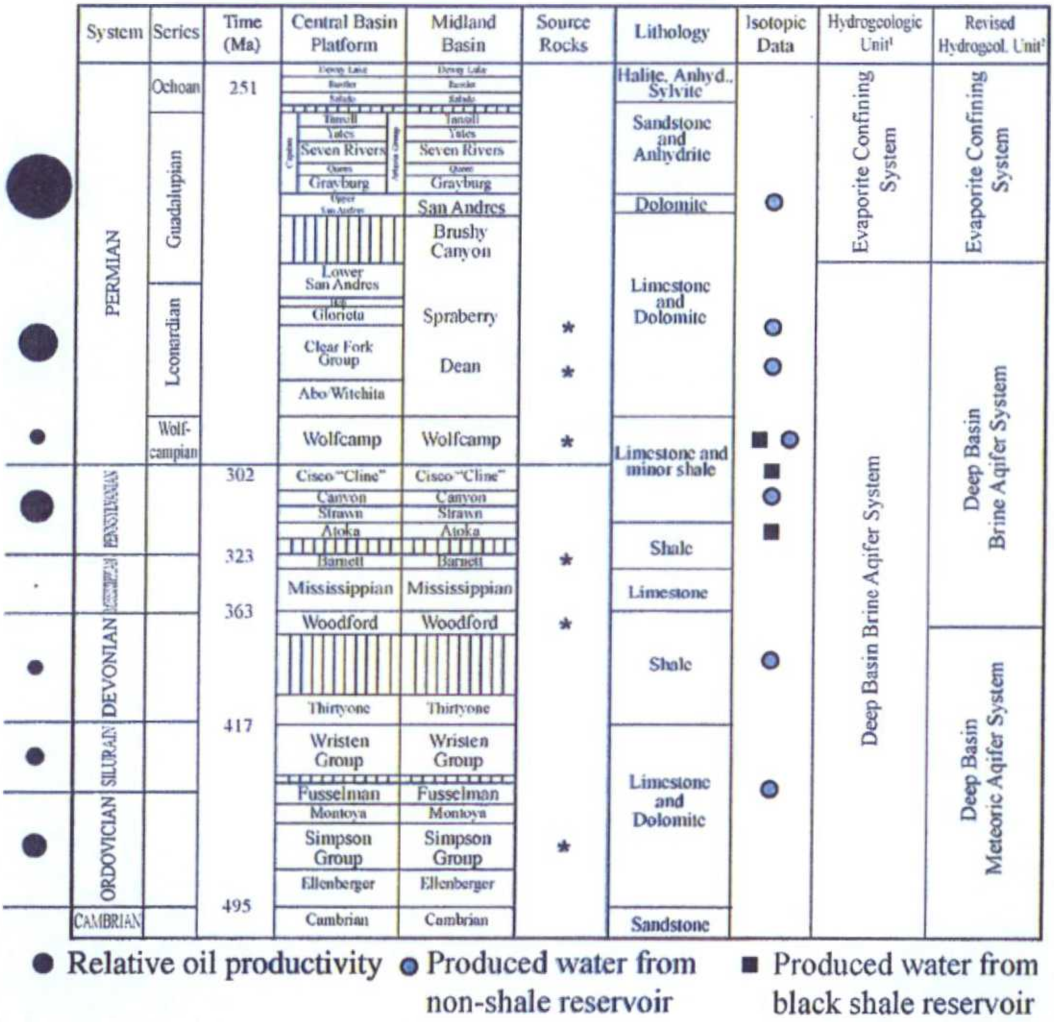


Fig. 2. Generalized stratigraphy of the Paleozoic Era of the Central Basin Platform and Midland Basin, modified from Dutton et al. (2005). Isotopic data column indicates geologic units with isotopic data for produced water samples. ¹Hydrogeologic units of Bassett and Bentley (1982). ²Suggested revision based on findings from this paper.

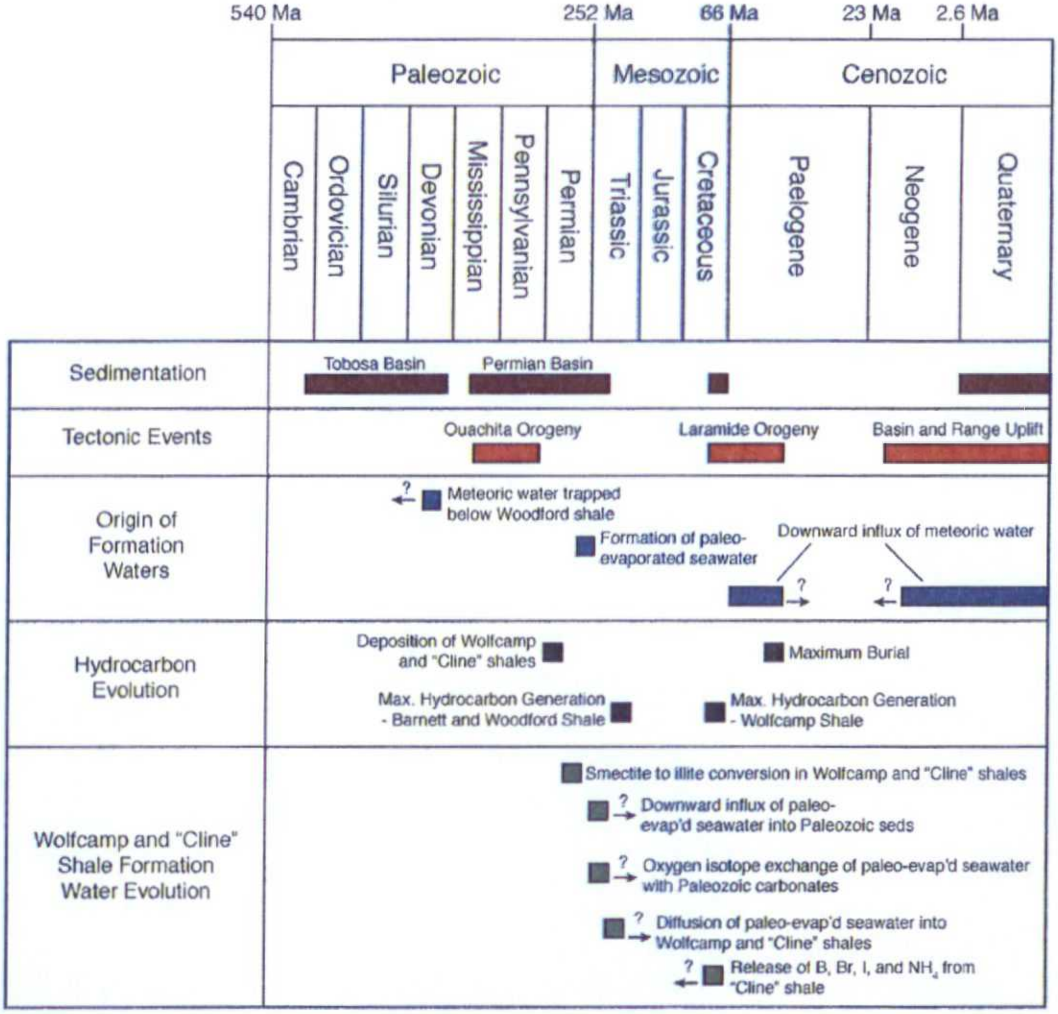


Fig. 3. Relative timing of events related to sedimentation, tectonic events, hydrogeology, water–rock interaction, and hydrocarbon evolution in the Permian Basin. Sedimentation, tectonic events, and hydrocarbon related events taken from literature cited in Section 2.

(referred to by drillers as the "Cline" shale and often divided into Upper and Lower units) and throughout the Wolfcampian rocks (Upper, Middle, and Lower Wolfcamp shale), are considered some of the most prolific source rocks of the basin (Dutton et al., 2005) and a large contributor to recent tight oil production. Wolfcampian and Pennsylvanian strata, including the Wolfcamp and "Cline" shales, thicken to the southeast toward

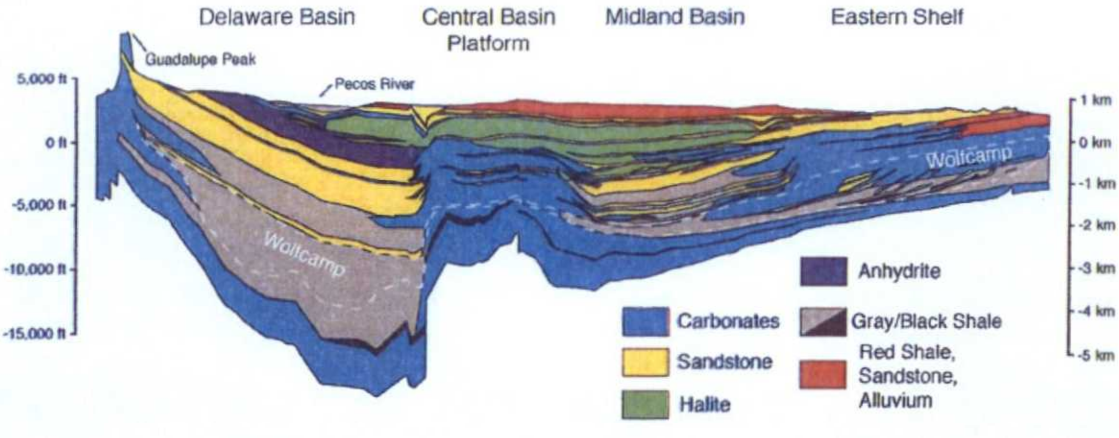


Fig. 4. Generalized geologic cross-section of the Permian Basin along the transect shown in Fig. 1. Modified from Matchus and Jones (1984).

the foredeep of the Ouachita Mountains (Hamlin and Baumgardner, 2012). Results from modeling of the Delaware Basin (Sinclair, 2007), suggest that maximum hydrocarbon generation in the deeper shales (e.g., Barnett and Woodford) occurred during the Permian, while the Wolfcamp shale achieved maximum hydrocarbon generation during the Late Cretaceous (Fig. 3). Along the edges of the Midland Basin, these units consist of platform carbonates with siliciclastics and detrital carbonate filling the basin center (Dutton et al., 2005). Lithologically, Wolfcampian and Pennsylvanian mudrocks are categorized as either calcareous mudrocks or non-calcareous mudrocks, depending on the relative contribution of carbonate minerals versus silt (Hamlin and Baumgardner, 2012). Mineralogically, the mudrocks contain quartz, feldspars, calcite, dolomite, clays (illite, smectite, chlorite and kaolinite), and less commonly pyrite and phosphate nodules (Hamlin and Baumgardner, 2012). Clays in the Wolfcampian mudrocks appear more diagenetically mature, showing substantial smectite to illite conversion (often >70% illite with R3 ordering) and higher abundances of secondary products of diagenesis (i.e., Fe-rich carbonate minerals, silica, and mixed illite–chlorite clays), than the R0 and R1 type mixed-layer clays in Pennsylvanian-age (Atokan) source rocks (Sivalingam, 1990). The availability of K in the reservoirs appears to be the primary reason that shallower Wolfcamp shale reservoirs have experienced a higher degree of diagenesis than the deeper, K-poor Pennsylvanian age shales (Sivalingam, 1990).

Previous authors studying formation brines in the area (Bassett and Bentley, 1982), primarily along the northern reaches of the Permian Basin and into the Palo Duro Basin, divided the Paleozoic strata into two hydrogeologic units (Fig. 2): 1) an Evaporite Confining System composed of halite, gypsum, and other evaporite minerals in the Ochoan and sandstone, anhydrite, and dolomite of the Guadalupian; 2) and the underlying Deep Basin Brine Aquifer System of alternating carbonates and shale, comprising all older water-bearing units. Several authors have pointed to meteoric water entering the Deep Basin Brine Aquifer System along structures in the western margins of the Permian Basin, increasing in salinity through the dissolution of evaporite minerals, and displacing older evaporated paleoseawater derived brines in piston-style flow (Barnaby et al., 2004; Bein and Dutton, 1993; Lambert, 1992; Stueber et al., 1998). However, more recent investigations of produced waters from Guadalupian reservoirs of the Delaware Basin and Central Basin Platform suggests that meteoric-derived brines are more limited in geographic extent than previously thought (Engle and Blondes, 2014).

Sinclair (2007) suggests that maximum burial of sediments in the Permian Basin occurred during the Early Eocene and was followed by uplift during the Laramide Orogeny (55–50 Ma) and Basin and Range extension (25–10 Ma). These two events removed an estimated ~1200 m and ~1100 m of sediment, respectively, from the basin. Studies from the adjacent Palo Duro Basin suggest that associated uplift and tilting created under-pressuring in portions of the Deep Basin Brine Aquifer System, due to low vertical hydraulic conductivity in the thick evaporite layers, and eastward groundwater flow (Senger et al., 1987). Although over-pressuring has been observed in some reservoirs of the Delaware Basin (Hansom and Lee, 2005; Luo et al., 1994), under-pressuring in much of the Deep Basin Brine Aquifer System is inferred (Hunt, 1990). Thus, our conceptual model for present-day fluid flow in the study area is slow, but net downward flux of meteoric water from Cenozoic and Mesozoic aquifers, through the Evaporite Confining System, and into the underlying Deep Basin Brine Aquifer System, with west-to-east horizontal flow across the basin (Bein and Dutton, 1993).

3. Methods

A total of 39 (plus additional Quality Assurance/Quality Control samples) produced water samples were collected in the study area (Fig. 1) from reservoirs of Leonardian to Silurian age (Fig. 2). To better represent formation waters, rather than fluids injected for fracture stimulation, sampling was limited to wells that had been in production for more than 30 days (median value was 160 days post-production and maximum value was almost 2.5 years post-production). In addition, sampling was avoided in areas of current or historical water flooding or enhanced-oil recovery activities. With the exception of two multiple-well stock tank samples (14-TX-39B and 14-TX-40B), all samples were either collected from the production string at the pumpjack or from a separator, both of which are closed off from the atmosphere. Samples were collected in collapsible 2.5 gal carboys (Cubitainers), and processed in a manner similar to that of Kharaka et al. (1987). The carboys were inverted to allow water to settle to the bottom, below the oil and gas fractions. Water was removed through a spigot at the base of the carboy that flowed through silicone tubing to a filter assembly. The flow of water was controlled by a peristaltic pump (GeoPump2). The closed, collapsible nature of the carboy allowed for the water to be removed without exposing the samples to air. The spigot and tubing were pre-cleaned with 5% trace-metal grade nitric acid. For field parameters, a PFTE filter cartridge containing glass wool was used to remove residual oil. For ionic and organic samples, the glass wool filter was removed and replaced with a 0.45 μm capsule filter (Geotech). The carboy, silicone tubing, glass wool, and capsule filter were disposed of after each sample.

Both field parameters and laboratory measurements of brines require special methods to account for high salinity. A toroidal sensor (Omega Engineering Model CDTX-45T1), which can handle the range of high salinity samples and is not fouled by hydrocarbons or other compounds, was used to measure specific conductance (calibrated using a 200 mS/cm solution). An empirical temperature correction factor of 1.91%/°C, determined through laboratory measurements on one of the samples over a range of 10 °C to 40 °C, was applied to each field measurement. Because high salinity samples exhibit a different reference voltage than conventional pH buffers used to calibrate the instrument (Marcus, 1989), the buffers were mixed with ~85 g NaCl/L to approximate the salinity and composition of the samples. As the addition of salt to the buffers affects their pH, by changing the activity of hydrogen ions, a Pitzer-based geochemical model was used to determine the final pH of the fortified pH buffers (at 25 °C the 4.01 buffer became 3.99, the 7.00 buffer became 6.91, and the 10.0 buffer became 9.83). This method, modified from Nir et al. (2014), corrects for both differences in the activity coefficient and reference voltage in pH meters in high salinity waters. A double-junction electrode (Thermo Scientific Model ROSS 8165BNWP) was utilized to measure pH in the field, in an attempt to minimize potential of fouling of the reference electrode by sulfide. Both the pH and specific conductance units were calibrated daily and after each sampling event; no noticeable drifts were observed. Lastly, specific gravity was measured in the field using graduated hydrometers, following ASTM Method D1429-D.

Three aliquots were collected for each sample: 1) filtered and acidified (>2% distilled HNO_3) for cations, I^-, $\delta^{11}B$, and $^{87}Sr/^{86}Sr$ analyses; 2) filtered samples for anions and total dissolved solids (TDS); and 3) filtered samples in a glass, amber bottle for alkalinity, dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and isotopes of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) in water. Cations and metals were analyzed via inductively coupled plasma-optical emission spectrometer (ICP-OES), iodide by ion specific electrode (ASTM D3869 — Method C), alkalinity by gran titration, and TDS by evaporation at 180 °C, all at the Department of Geological Sciences at the University of Texas of El Paso (UTEP). Anions and select cations were analyzed by ion chromatography (IC) and DIC and DOC were determined using a LICO elemental analyzer at the Energy and Environmental Lab at the U.S. Geological Survey in Reston, Virginia. Slightly better calibration data were obtained for the alkali elements from the IC method versus ICP-OES, so the IC data are reported here. Charge balances are <5% for all samples, absolute differences between field blanks ($n = 4$ sets) were typically <5%, and errors in the elemental reference standards (USGS M-178, M-182, T-143) were typically <10% for all elements wherein the reported values were within the calibrated range. Stable isotopes of $\delta^{18}O$ and $\delta^{2}H$ in water, were measured by the U.S. Geological Survey Stable Isotope Lab in Reston, Virginia. Corresponding $\delta^{18}O$ and $\delta^{2}H$ data were converted from an activity basis to a concentration basis using the empirical methods of Sofer and Gat (1972, 1975).

Boron and Sr isotope measurements were carried out on a Nu Plasma multiple collector-inductively coupled plasma-mass spectrometer at the Center for Earth and Environmental Isotope Research at UTEP, following column separation in a class-100 clean room. For B, chemical separation was completed using Amberlite IRA 743 resin, following the method of Eppich et al. (2011). Data are compared to NIST 951a standard and reported in units of per mil (‰). In some samples, Fe was observed precipitating in the resin during chemical separation and was presumably transferred into the sample during elution in 2% HNO_3. However, Fe-spiked NIST 951a standard (20:1 Fe to B mass ratio) and column separated, Fe-spiked (20:1 and 5:1 Fe to B mass ratios) IAEA B-1 seawater secondary standard produced results within reported values, suggesting that Fe had no measureable impact on the analytical results. Repeated analysis of the NIST 951a standard ($n = 14$) provides an uncertainty (2s) of 1.08‰. The median value of 40.8‰ for the secondary standard, IAEA B-1, is within the range of its accepted value of 38.6 ± 3.4 ($\bar{x} \pm 2s$). For Sr, the samples were passed through Eichrom Sr-resin, dried down, and brought up in 2% HNO_3. Strontium data were corrected on-line for interferences with Kr (Konter and Storm, 2014). For the Sr isotopic measurements, the internal standard (SRM 987) exhibited an external error (2s) of 0.00016 over the 4-day analytical run, and the secondary standard (EN-1 Tridachna shell) provided a mean value of 0.70917 ± 0.00003 ($n = 8$) relative to the accepted value of 0.70917, suggesting acceptable analytical performance. Field blanks contained negligible amounts of Sr and B.

To supplement the results collected here, data for an additional 1374 produced water samples from within the study area (Fig. 1) were taken from the USGS National Produced Waters Geochemical Database, Version 2.1 (ions only; Blondes et al., 2014) and another 32 data points including results for ions, $\delta^{18}O$, $\delta^{2}H$, and $^{87}Sr/^{86}Sr$ from a study by Stueber et al. (1998) on the edge of the Central Basin Platform (Fig. 1). These additional datasets pre-date tight oil development in the Basin and are presumed to correspond to conventional, non-shale reservoirs. Like the data collected for this study, the samples from the Stueber et al. (1998) study were collected only in areas outside of current or historical water flooding or CO_2 injection. However, the impact of water flooding and CO_2 injection on the data in the USGS National Produced Waters Geochemical Database is unknown. Analysis using the database in a different portion of the Permian Basin suggested that roughly 10% of the data were impacted by water flooding (Engle and Blondes, 2014). Samples with charge imbalances > 10% were excluded from analysis and are not counted in the sample totals provided here.

Ionic and elemental data are compositional, meaning that they are parts or relative amounts of some whole, and require special mathematical treatment. As noted in several papers (Engle and Blondes, 2014; Engle and Rowan, 2013, 2014), the exceptionally large range in salinities of formation waters tends to exacerbate problems associated with application of conventional data analysis to brine chemistry and make the data prone to spurious relationships. Intuitively, this is because the sum of masses or volume of the various solutes changes as a function of the water content (i.e., inverse of salinity), such that when the water content varies widely, the other solutes are artificially constrained to have a positive correlation. In some cases, the impact to the interpretation of brine geochemical data can be substantial, such as suggested mixing between end-members which is not actually occurring (Engle and Rowan, 2013). To avoid these documented issues, non-isotopic data in this paper are treated using standard compositional data analysis (CoDa) methods, which were developed specifically to overcome problems in traditional approaches (e.g., concentration vs. concentration plots). In this case, subcompositions of multivariate concentration data were converted using an isometric log-ratio (ilr) transformation prior to interpretation and plotting. The most common method for doing so is to convert D number of constituents, or parts, to $D - 1$ series of non-overlapping groups of parts known as a sequential binary partition (Egozcue and Pawlowsky-Glahn, 2005), which can be arranged to maximize geochemical interpretation (Engle and Blondes, 2014; Engle and Rowan, 2013). The corresponding ilr coordinates (z_i) are calculated using the sequential binary partition via:

$$z_i = \sqrt{\frac{r_i s_i}{r_i + s_i}} \ln \frac{(\prod x_j)^{\frac{1}{r_i}}}{(\prod x_l)^{\frac{1}{s_i}}}, \text{ for } i = 1, \ldots, D-1, \tag{1}$$

where r_i and s_i are the number of parts coded with $+1$ and -1, respectively, and x_j and x_l are the constituents coded with and $+1$ and -1, respectively. For a 2-part subcomposition, say molar concentrations of Na and Cl, the resulting ilr coordinate would be:

$$z_1 = \frac{1}{\sqrt{2}} \ln \frac{[\mathrm{Na}]}{[\mathrm{Cl}]} \text{ or } z_1 = \frac{1}{\sqrt{2}} \ln \frac{[\mathrm{Cl}]}{[\mathrm{Na}]} \tag{2}$$

depending on the chosen arrangement of the sequential binary partition. Once data are transformed into ilr coordinates, they follow the standard Euclidean geometry and can be used or analyzed directly using conventional techniques. Isotopic data, for practical reasons, are not readily affected by the mathematical problems that impact concentration data and their conversion to ilr coordinates provides no substantial benefits (Blondes et al., 2015; Tolosana-Delgado et al., 2005), so they are kept in their original units.

In addition to geochemical data, formation pressure data were compiled for wells in Upton, Reagan, and Irion counties, which form the southern extent of the study area (Fig. 1). One hundred and eighteen pad initial shut-in pressure measurements for lower permeability layers in the Spraberry and Dean (both Leonardian) and from the Wolfcamp shale were taken from Friedrich and Monson (2013). Drill stem test shut-in pressure data from a proprietary database (IHS Energy)

Table 1

Geometric centers for formation water sample data from the Wolfcamp shale, non-shale Wolfcampian reservoirs, the "Cline" shale, and non-shale Pennsylvanian reservoirs within the study area. Units are percent of total solute mass.

	Wolfcamp shale	Wolfcampian	Ratio		"Cline" shale	Pennsylvanian	Ratio
Cl	6.05E−01	6.04E−01	1.00	Cl	5.75E−01	6.06E−01	0.95
Na	3.56E−01	3.13E−01	1.13	Na	3.57E−01	3.17E−01	1.13
Ca	1.77E−02	4.93E−02	0.36	Ca	2.40E−02	5.13E−02	0.47
K	4.99E−03	4.92E−03	1.01	Br	1.49E−02	2.67E−03	5.61
Br	4.87E−03	4.86E−03	1.00	Sr	1.04E−02	2.47E−03	4.19
SO_4	4.57E−03	9.03E−03	0.51	SO4	6.70E−03	6.01E−03	1.12
Sr	3.31E−03	3.55E−03	0.93	K	3.24E−03	4.00E−03	0.81
Mg	2.64E−03	8.78E−03	0.30	Mg	3.22E−03	9.87E−03	0.33
I	5.61E−04	8.60E−04	0.65	I	2.60E−03	1.71E−04	15.20
DIC	5.40E−04	3.30E−04	1.64	DIC	1.10E−03	2.83E−04	3.87
B	3.15E−04	3.21E−04	0.98	B	6.62E−04	1.81E−04	3.65
Li	2.37E−04	1.23E−04	1.94	Li	4.33E−04	9.59E−05	4.52
Si	1.06E−04	5.60E−05	1.89	Si	3.94E−04	7.17E−05	5.49

Table 2
Comparison of 1st and 3rd quartiles for water chemistry data from major tight oil and shale gas reservoirs. Bakken and Marcellus Shale data taken from the USGS National Produced Waters Geochemical Database, Version 2.1 (Blondes et al., 2014). n = number of data. Units are mg/L for all constituents except for pH (pH units).

	Wolfcamp shale – tight oil			"Cline" shale – tight oil			Bakken – tight oil			Marcellus shale – shale gas		
	Quartile 1	Quartile 3	n	Quartile 1	Quartile 3	n	Quartile 1	Quartile 3	n	Quartile 1	Quartile 3	n
pH	7.1	7.6	14	7.5	7.7	9	5.63	6.42	420	5.9	6.8	26
Alkalinity as HCO_3	412	755	14	695	1116	9	122	281	415	24.7	87.2	26
B	32.4	42.5	14	31.6	37.8	9	208	489	13	10.0	22.7	24
Ba	<20	<20	14	<20	<20	9	12.0	31.8	309	282	2605	26
Br	493	639	14	585	928	9	521	874	11	604	1126	26
Ca	1463	2762	14	647	2451	9	7142	17000	425	6055	18950	26
Cl	63052	75370	14	19750	46330	9	116399	177769	425	50475	116064	26
Fe	19.7	55.2	14	63.9	183	9	17.5	129	383	31.825	78	26
I	62.8	80.6	14	94.8	184	9	No data	No data	0	No data	No data	0
K	388	902	14	126	212	9	2598	5305	372	271	867	19
Li	25.8	28.5	10	19.5	27.3	9	7.32	57.4	16	48.0	127	25
Mg	222	384	14	84.7	329	9	667	1335.6	425	347	1675	26
Mn	<0.5	1.18	14	1.59	3.07	9	4.04	10.8	11	2.36	9.63	25
NH_4	633	1334	10	98.0	229	9	1500	2500	11	87.7	237	25
Na	38101	45095	14	12876	25207	9	57900	91700	425	26850	43742	26
Si	11.1	13.3	14	17.1	23.6	9	No data	No data	0	No data	No data	0
SO_4	363	649	14	<300	<300	9	305	760.5	422	7.3	50	25
Sr	316	421	14	293	931	9	921	1450	13	1042	3693	26
TDS	105408	123227	14	36790	79920	9	194559	292973	377	88500	199000	25
DOC	79.9	206	14	166	228	9	No data	No data	0	32.0	305	17

provided an additional 1,374 points from Guadalupian to Ordovician age reservoirs for the same three counties. Data were converted to pressure gradients to adjust for differences in reservoir depth across the study area by dividing the reservoir pressure data by the average depth of the test interval for each data point. All data with a pressure gradient less than 4.5 kPa/m were discarded as being unrealistically low.

4. Results and discussion

4.1. Geochemical characterization of Wolfcamp and "Cline" shale formation waters

Geometric centers (the geometric mean of each constituent, normalized to 100%) were used to estimate the average relative abundance of solutes by mass for produced water samples from four unique sets: 1) the Wolfcamp shale (n = 14); 2) the "Cline" shale (n = 9); 3) non-shale, Wolfcampian reservoirs; and 4) non-shale Pennsylvanian reservoirs (Table 1). By comparing the composition of produced waters from shale versus non-shale reservoirs of the similar age (Wolfcampian and Upper Pennsylvanian), it allows us to examine unique geochemical signatures and processes which affect waters found in the Permian Basin shales, where less information exists in the literature. The simple approach of determining the geometric center of each sample set is a compositional technique for approximating the multivariate barycenter of the data, while considering that the individual parts of the various solutes must sum to 100% (see Engle and Rowan [2014] for additional application of geometric centers to brine analysis). The resulting geometric centers for formation waters from Wolfcamp and "Cline" shales indicate that the solutes in sets of samples are comprised of Cl (57.5–60.6%) and Na (31.3–35.7%), with minor Ca (~5%). On average, no other constituents are present in excess of 1% by solute mass. Geometric centers for both sets also show similar relative solute abundances of Br, I, K, Mg and SO_4 (0.01% to 0.3% by solute mass) with the smallest contribution from DIC, B, Li, and Si. To allow for comparison, this analysis only includes results for elements measured/reported in all four sample sets; additional parameters of interest for these samples were examined in univariate analysis.

To gain a sense of how formation waters from the Permian Basin shale reservoirs compare to those of other shale gas and tight oil plays, univariate statistics for selected constituents in Wolfcamp and "Cline" shale produced water samples are shown with those for the Bakken (Williston Basin) tight oil and Marcellus Shale (Appalachian Basin) gas plays, taken from the USGS National Produced Waters Geochemical Database, Version 2.1 (Blondes et al., 2014). To emphasize "typical values" from formation waters, the 1st and 3rd quartiles are compared (Table 2). Use of log-ratio transformations for calculation of univariate percentile-based statistics are unnecessary because the same results are produced from the raw data (Filzmoser et al., 2009). The ranges of solute concentrations from the Wolfcamp shale samples are generally of the same order of magnitude as those from the Bakken and Marcellus Shale, but they exhibit higher pH and relatively little Ba, Ca, Mg, and Sr compared to Na. Compared to the other sets, samples of produced waters from the "Cline" shale have lower salinity (typically <80 g/L) with elevated abundances of Br and I. Data for all of these reservoirs contain elevated concentration of NH_4 (often > 100 mg/L), which is unsurprising as the denitrification of organic matter in source rocks is a known source of NH_4 (Pashin et al., 2014). High ratios of alkali to alkaline earth elements and the relatively low salinity in the Permian Basin samples relative to the Bakken and Marcellus shales suggests that their origin is unique and invites further examination.

4.2. Comparison of formation water geochemistry for Wolfcamp and "Cline" shales versus adjacent formations

For a gross overview of the data, molar Na/Cl and Ca/SO_4 ratios are useful for discrimination of formation water chemistry (Hounslow, 1995). Keeping with the application of CoDa techniques, for each sample the four parts of interest (Ca, Cl, Na, and SO_4) were converted to three ilr balances using a sequential binary partition (Table 3) following the rules of Egozcue and Pawlowsky-Glahn (2005). The partition was arranged to allow for direct comparison of the molar Na/Cl and Ca/SO_4 ratios in balances 2 and 3. The resulting transformed data for these two balances are plotted in Fig. 5. Nearly all of the samples from the study area fall into the category of Ca–Cl-type brines, meaning that on an equivalence

Table 3
Sequential binary partition for the subcomposition [Ca, Cl, Na, SO_4], where + indicates that part is in the numerator of the ilr balance, − indicates that the part is in the denominator of the ilr balance, r is the number of parts in the numerator, and s is the number of parts in the denominator. Parts with neither − or + are not used in that balance.

Partition	Na	Cl	Ca	SO_4	r	s
1	+1	+1	−1	−1	2	2
2	+1	−1			1	1
3			+1	−1	1	1

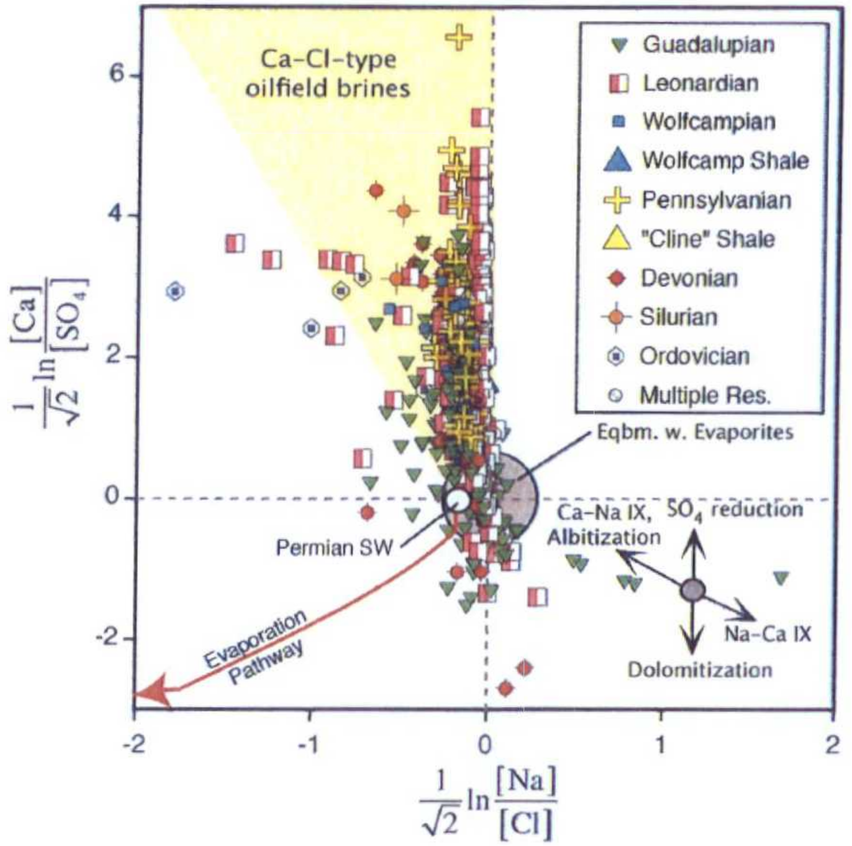


Fig. 5. Scatterplot of two isometric log-ratios for the subcomposition [Ca, Cl, Na, SO_4], using molar data. Also shown are the composition of Late Permian seawater (SW) and its modeled trajectory for evaporation (solid red line) and the approximate compositions of water in equilibrium with halite and anhydrite (gray circle). Multiple Res. = well producing from multiple reservoirs, IX = ion exchange.

basis they have more Ca than HCO_3, CO_3, and SO_4. Two potential sources of solutes, dissolution of evaporites (anhydrite and halite) and evaporated Late Permian seawater are shown on the plot, but the vast majority of data are distal to both. In fact, most of the sample data plot well above both sources on the y-axis, suggesting that SO_4 reduction has been an important process in defining the composition of formation waters from the basin. Comparison of data for formation water samples from the Wolfcamp and "Cline" shales with the adjacent non-shale reservoirs in this plot shows no obvious patterns of separation, indicating a common origin. Some of the data, particularly for samples from Guadalupian, Leonardian, and Devonian reservoirs, plot distal to the rest of the data and away from the various solute sources. These scattered data are from the USGS National Produced Waters Geochemical Database, which does include data impacted by water flooding (Engle and Blondes, 2014) and may represent mixtures of formation water with water from other sources or erroneous chemical data. Alternatively, these same compositions can be achieved through exchange of Na for Ca on clay minerals from waters in equilibrium with anhydrite and halite. Engle and Blondes (2014) previously noted that Na–Ca exchange is an important reaction in some Guadalupian-age reservoirs in the Permian Basin.

Examining the behavior of Na, Cl, and Br in saline waters has long been used to indicate the origin of salinity in brines, because Br has little affinity for halite (McCaffrey et al., 1987; Walter et al., 1990). The conventional approach is to examine either the concentrations of Cl vs. Br (or Na vs. Br) or the ratios of Na/Br vs. Cl/Br. For comparison, we show those two plots (Fig. 6) against the isometric log-ratio Na–Cl–Br graph of Engle and Rowan (2013), for the purpose of highlighting some advantages of application of compositional data analysis to brine geochemistry relative to traditional approaches. A more detailed comparison between these various plots using different datasets is provided in Engle and Rowan (2013).

The three plots (Fig. 6) show the different geochemical pathways for the evaporation of Late Permian seawater versus dissolution of Br-poor halite by paleoseawater (creation of pathways described in Engle and Blondes, 2014; Engle and Rowan, 2013) based on the assumption that halite has no affinity for Br. Plotting of Permian Basin produced water data on a Cl vs. Br concentration plot (Fig. 6A) shows that many of the data for samples from Guadalupian and some of the data from Leonardian reservoirs plot along or near the trend for halite dissolution, while those from deeper reservoirs (except for those from the Wolfcamp and "Cline" shales and the remaining Leonardian samples) generally plot along the trajectory for Late Permian seawater evaporation, prior to halite saturation. Of the remaining samples, data from the Wolfcamp shale and some of the Leonardian samples appear to plot along a mixing pathway between weakly evaporated Permian seawater and highly evaporated Permian seawater (beyond halite saturation), while those for "Cline" shale plot away for all indicated processes controlling Br and Cl.

By comparison, results using the Cl/Br vs. Na/Br plot of Walter et al. (1990) show somewhat similar results (Fig. 6B). On this type of plot, for samples to lie along the seawater evaporation curve they have to have been evaporated beyond the point of halite saturation. Therefore, results from this plot indicate that most samples which plot along the evaporation pathway are more strongly evaporated (i.e., beyond halite saturation) than suggested by the Cl vs. Br concentration plot. Moreover, on the Cl/Br vs. Na/Br diagram, data for samples for shale reservoirs plot on the far end of the seawater evaporation curve, although with a lower Cl/Br molar ratio than would be expected purely from Late Permian seawater evaporation. If the Wolfcamp shale and a portion of the Leonardian reservoirs data do represent mixing (as suggested in the Cl vs. Br concentration plot), this plot suggests brines from the "Cline" shale may be the highly evaporated end-member (which is not supported by the concentration plot or by TDS data [Fig. 7]).

Interpretation of the isometric log-ratio Na–Cl–Br plot (Fig. 6C), an application of CoDa, shows similar results to the other two plots with some important exceptions. As before, data for samples from Guadalupian, some Leonardian, and some Devonian data plot along the curvilinear pathway (where the molar Na/Cl ratio approaches 1 and abundance of Na and Cl relative to Br, increases) for halite dissolution, suggesting these are meteoric waters that derived their salinity from upper Permian evaporite minerals. On this type of plot, mixtures of highly evaporated seawater and less evaporated seawater (as suggested for the Wolfcamp shale data by the Cl vs. Br concentration plot) fall along the seawater evaporation trajectory (Engle and Rowan, 2013). So, unlike the other two plots, formation waters from the Wolfcamp shale do not appear to represent mixtures of strongly and weakly evaporated seawater. In fact, very few samples plot along the seawater evaporation pathway. Rather, data for Wolfcampian, Wolfcamp shale, Pennsylvanian, "Cline" shale, and a portion of the Leonardian reservoir samples plot off the seawater evaporation pathway. This pattern is most pronounced for "Cline" and Wolfcamp shale formation water data, which appear to show an exceptional enrichment in Br relative to Na and Cl, and enrichment of Na relative to Cl. The former suggests input from a Br source in addition to or other than evaporated seawater. Addition of external Br would produce an exaggerated degree of evaporation in the Cl/Br vs. Na/Br plot and explain why "Cline" and Wolfcamp shale sample data in this plot indicate evaporation well beyond halite dissolution, despite showing lower TDS values than the data for non-shale Pennsylvanian and Wolfcampian reservoirs (Fig. 7). In the Cl. vs. Br concentration plot, input of external Br would push samples to the right of the evaporation pathway in creating an apparent mixing pathway for the Wolfcamp shale samples that may not truly exist. Enrichment in Na relative to Cl in the ilr plot, was not identified in the other plots and is important as it suggests additional processes that controlled the relative abundance of cations (as detailed further in Section 4.3). In this case, results from the ilr Na–Cl–Br plot (Fig. 6C) produce the most internally consistent interpretations and identify processes which were not seen in the other plots. This example highlights the advantages of application of CoDa techniques to the interpretation of brine geochemical data, and is justification for their usage here. Because data from many of the samples, including those from the shale reservoirs, fall off the modeled trajectories in the ilr Na–Cl–Br plot, application of Na–Cl–Br systematics to interpret the origin of brines to Permian Basin samples needs to be used with caution. In addition to the lack of clarity due to an external source of Br (e.g., organic-matter derived halogens), previous authors suggest that recycling of halite in the nearby Palo Duro Basin was common along basin margins (Hovorka et al., 1993), which may further complicate Na–Cl–Br systematics in Permian Basin brines.

As a final means to examine geochemical differences among formation waters found in shale reservoirs and adjacent non-shale reservoirs, histograms of TDS concentrations (Fig. 7) and compositional geometric centers (Table 2) of produced water samples from different reservoirs were examined. In general, following the modes of the histograms, TDS increases as a function of reservoir age (a proxy for depth), down to the Devonian-age reservoirs (up to and exceeding 200,000 mg/L), then decreases to <150,000 mg/L in water samples from older, deeper reservoirs (Fig. 7). Some of the lower TDS values in the conventional reservoirs may be a result of the injection of shallow meteoric water during water flooding. Formation waters from the shale units are typically 75,000–100,000 mg/L less saline than water from the adjacent, non-shale reservoirs, suggesting marked differences in formation water geochemistry between shale and non-shale reservoirs of similar age. For the Wolfcampian-age reservoirs, relative abundances of B, Br, Cl, and K were similar between geometric centers for the shale versus non-shale reservoirs (Table 2). However, the produced water samples from the Wolfcamp shale are enriched in DIC, Li, Na and Si and depleted in Ca, I, Mg, and SO_4 compared to their relative abundances in data for Wolfcampian non-shale reservoirs. Differences based on reservoir lithology were even more pronounced in the relative abundances of constituents for "Cline" shale samples versus non-shale Pennsylvanian reservoirs; samples from the shale reservoirs are heavily enriched in Br, B, DIC, I, Li, Si, and Sr, moderately enriched in Na and SO_4, and heavily depleted in K, Ca, and Mg relative to data from the non-shale reservoir samples.

Breakdown of Type-II, marine kerogen is a known source of halogens (Br and I), NH_4, and B to formation waters (Moran, 1996; Pashin et al., 2014; Williams et al., 2001b; Worden, 1996). The associated enrichment of these constituents in formation waters from the "Cline" shale relative to those from non-shale Pennsylvanian reservoirs suggests that thermal maturation of kerogen is an important control on the composition of the produced waters from mature source rocks. Additional evidence for contribution of elements from kerogen to formation waters from the "Cline" shale comes from $\delta^{11}B$ and Cl data. Strictly following rules for CoDa, a 3-part singular binary partition for this system was created (Table 4). To simplify the associated ilr coordinates, z_1 was changed from

$$\sqrt{\frac{2}{3}}\ln\frac{\sqrt{[^{11}B][^{10}B]}}{[Cl]} \tag{3}$$

to

$$\frac{1}{\sqrt{2}}\ln\frac{[B]}{[Cl]} \tag{4}$$

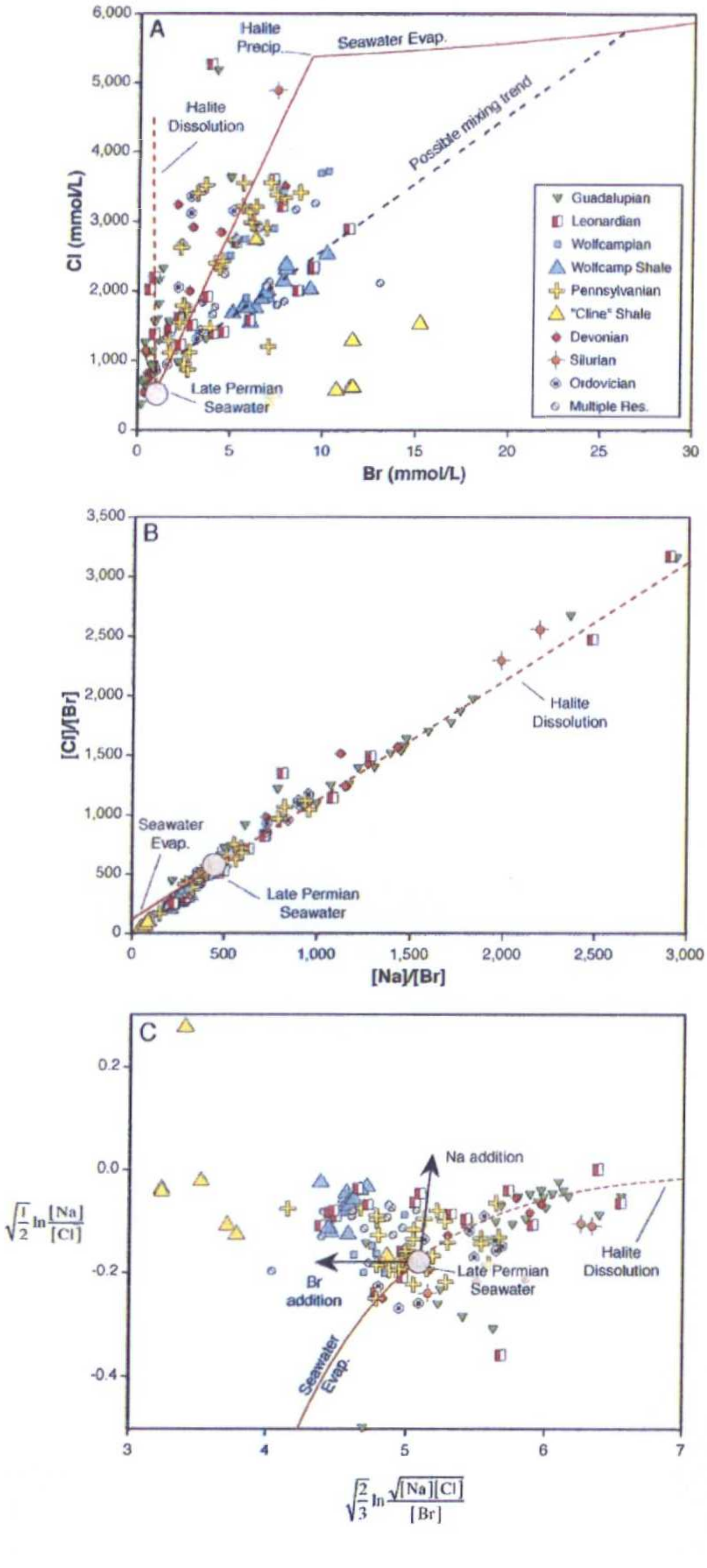
and z_2 was modified from

$$\frac{1}{\sqrt{2}}\ln\frac{[^{11}B]}{[^{10}B]} \tag{5}$$

to $\delta^{11}B$ (Fig. 8). This is justified because calculated values from the simplified formulas are highly correlated with those from the original coordinates ($R^2 > 0.9999$). Correspondingly transformed data for water from Leonardian and Wolfcamp shale reservoirs plot along the approximate trajectory for seawater evaporation (Vengosh et al., 1992) with a starting point for the estimated composition of Late Permian seawater (Joachimski et al., 2005). By comparison, data for the "Cline" shale water samples show enrichment in B/Cl by up to a factor of five, and exhibit isotopically lighter values of $\delta^{11}B$. Williams et al. (2001b) showed a similar pattern in formation waters from the Gulf Coast Basin and demonstrated that thermally mature marine kerogen is an important source of isotopically light B in some reservoirs, supporting this hypothesis.

Many of the other differences, in terms of salinity and solute composition, between formation waters from the shales versus adjacent, non-shale reservoirs cannot be explained by conventional mechanisms, such as preferential expulsion of solutes during physical compaction of clays (Engelhardt and Gaida, 1963; Rosenbaum, 1976) or release of interlayer water during smectite to illite conversion (Schmidt, 1973). These are sequential mechanisms (physical compaction occurs at 0–2 km burial and smectite to illite conversion at >3 km; Bjølykke, 1998), and the clay minerals of the Wolfcamp shale and less so the "Cline" shales have been

Fig. 6. A) Scatter plot of Cl versus Br concentration data; B) scatterplot of Cl/Br vs. Na/Br molar ratios of Walter et al. (1990); C) scatterplots for the ilr transformation of the [Na, Cl, Br] subcomposition. Further details on the ilr plot are found in Engle and Rowan (2013). Modeled pathways for Late Permian seawater evaporation (solid red line) and halite dissolution by seawater (dashed red line) shown on all plots. Multiple Res. = well producing from multiple reservoirs.


A
Halite Precip.
Seawater Evap.
Halite Dissolution
Possible mixing trend
Late Permian Seawater
Cl (mmol/L)
Br (mmol/L)
6,000
5,000
4,000
3,000
2,000
1,000
0
0
5
10
15
20
25
30
Guadalupian
Leonardian
Wolfcampian
Wolfcamp Shale
Pennsylvanian
"Cline" Shale
Devonian
Silurian
Ordovician
Multiple Res.
B
[Cl]/[Br]
[Na]/[Br]
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
500
1,000
1,500
2,000
2,500
3,000
Halite Dissolution
Seawater Evap.
Late Permian Seawater
C
Na addition
Br addition
Late Permian Seawater
Halite Dissolution
Seawater Evap.
0.2
0.0
-0.2
-0.4
3
4
5
6
7
$\sqrt{\frac{1}{2}}\ln\frac{[\mathrm{Na}]}{[\mathrm{Cl}]}$
$\sqrt{\frac{2}{3}}\ln\frac{\sqrt{[\mathrm{Na}][\mathrm{Cl}]}}{[\mathrm{Br}]}$

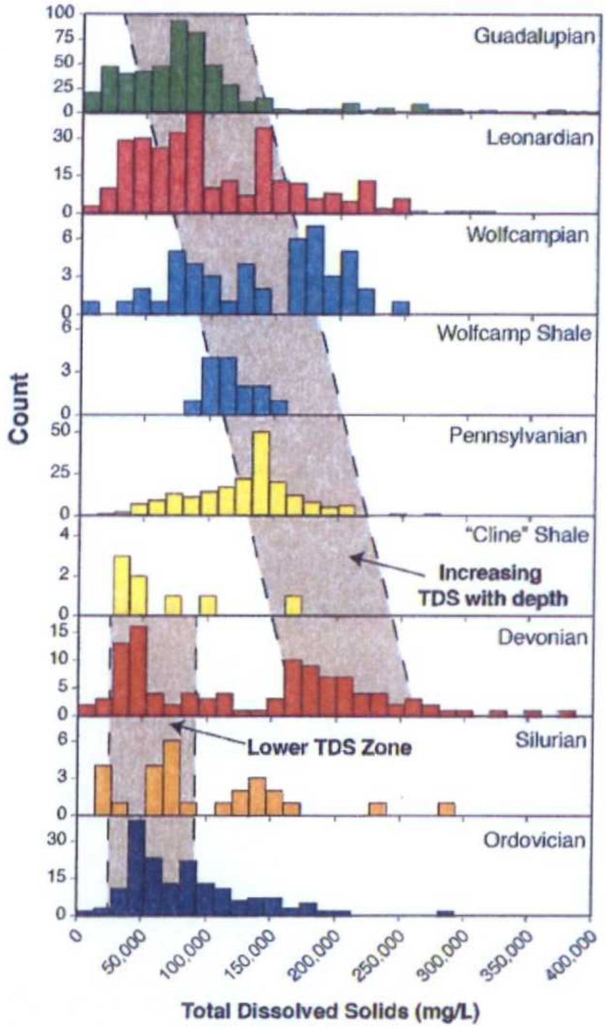


Fig. 7. Histograms of total dissolved solid (TDS) concentrations in produced water samples from Guadalupian to Ordovician reservoirs. Gray windows show trends in salinity with reservoir age drawn using modes of the histograms.

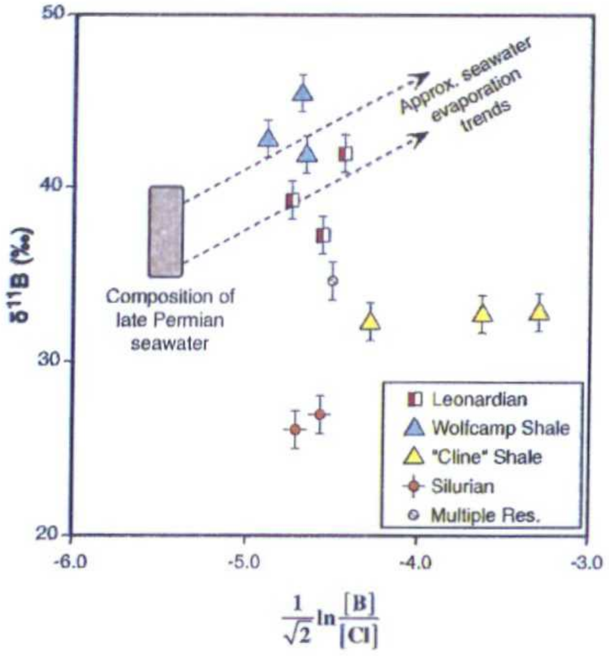


Fig. 8. Scatterplot of $\delta^{11}B$ versus ilr transformed molar B:Cl ratios. Also shown are the composition of Late Permian seawater from Joachimski et al. (2005) and the approximate trajectory for seawater evaporation calculated from data provided in Vengosh et al. (1992). Error bars in $\delta^{11}B$ data shown at 2 standard deviations, based on external precision. Multiple Res. = well producing from multiple reservoirs.

through diagenesis (Sivalingam, 1990). Thus, formation waters impacted by these mechanisms should show evidence for water-rock interactions related to smectite to illite conversion, namely depletion of K and preferential removal of ^{10}B, particularly in the more illite and chlorite-rich Wolfcamp shale (Schmidt, 1973; Williams et al., 2001a). Comparison of geometric centers between the shale and corresponding non-shale reservoirs (Table 1) and B composition and isotopic data (Fig. 8) show no evidence for either K or B loss (including preferential ^{10}B loss) in the water. Formation waters in the Wolfcamp and "Cline" shales thus appear to have entered these units after clay diagenesis was complete (Fig. 3). Processes other than clay diagenesis (discussed in the next section) were responsible for reducing salinity and changing the solute composition in the shale relative to water in the adjacent units.

Table 4
Sequential binary partition for the subcomposition [^{11}B, ^{10}B, Cl], where + indicates that part is in the numerator of the ilr balance, − indicates that the part is in the denominator of the ilr balance, r is the number of parts in the numerator, and s is the number of parts in the denominator. Parts with neither − or + are not used in that balance.

Partition	^{11}B	^{10}B	Cl	r	s
1	+1	+1	−1	2	1
2	+1	−1		1	1

4.3. Origin of formation waters in the Permian Basin

As described above, Na–Cl–Br plots help delineate the source of salinity in produced waters, but appear to be of limited help in understanding the origin of formation waters in the Permian Basin due to inputs of kerogen-derived halogens (particularly Br) and evidence from previous studies of recycling of halite near the basin margins of the hydrologically connected Palo Duro Basin (Hovorka et al., 1993; Knauth and Beeunas, 1986). Better evidence for origin of the brines can be yielded from δ^2H and $\delta^{18}O$ data (Dutton, 1987; Holser, 1979; Kharaka et al., 1987; Rowan et al., 2015), while insight into solute source is provided by $\delta^{11}B$ and $^{87}Sr/^{86}Sr$ data (Barnaby et al., 2004; Chapman et al., 2012; Moldovanyi et al., 1993; Williams et al., 2001b). Data for the elemental isotopes of water (Fig. 9) plot in proximity to the modern local meteoric water line (LMWL) of Reyes (2014), and the extent of data for primary and secondary fluid inclusions found in halite from the Palo Duro Basin (Knauth and Beeunas, 1986). Data for produced water samples from both the youngest (Guadalupian) and oldest (Devonian and Silurian) reservoirs plot near the modern local meteoric water line, suggesting that waters from these reservoirs are at least in part meteoric (Fig. 9). Samples from the same reservoirs host the lowest TDS concentrations, indicating meteoric contributions are an important source of lower salinity waters in the basin. Salinity data for formation waters for the Devonian-age reservoirs appear bi-modal, indicating that a potential vertical flow barrier may be present. Samples used here, from Devonian reservoirs, plot near the modern LMWL and exhibit TDS concentrations < 50 g/L confirming the likely source of the lower salinity water in these units. Previous authors have suggested that the Late Devonian Woodford Shale represents a vertical flow barrier in the system (Merrill et al., 2015), but the location of the study samples relative to the Woodford is unknown for confirmation of this hypothesis. It is

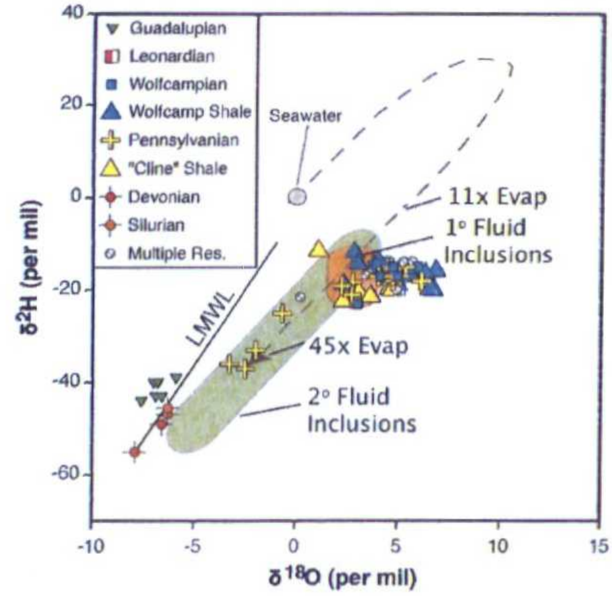


Fig. 9. Scatterplots of $\delta^{18}O$ and δ^2H data for produced water samples. Modern local meteoric water line (LMWL) from Reyes (2014). Also shown are the composition of seawater, the seawater evaporation trajectory of Holser (1979), and the composition of water in primary and secondary halite fluid inclusions from the Palo Duro Basin (Knauth and Beeunas, 1986). Multiple Res. = well producing from multiple reservoirs.

important to note that although the samples from Silurian reservoirs were collected distal to those from the Devonian reservoirs (Fig. 1), they still appear to be quite similar and follow TDS trends from the larger sample set indicating that patterns in the isotopic data are not likely controlled by local processes.

The remaining δ^2H and $\delta^{18}O$ data plot near the pathway for seawater evaporation (Holser, 1979), with the vast majority overlapping the range of data for primary fluid inclusions found within halite in the Palo Duro Basin, which are thought to represent evaporated Late Permian seawater (Knauth and Beeunas, 1986). A few of the data for samples from Pennsylvanian-aged reservoirs plot in the range of data for secondary fluid inclusions, which were interpreted to represent recycling of halite in the basin margins during inputs of continentally-derived freshwater into the system (Hovorka et al., 1993; Knauth and Beeunas, 1986). Such findings suggest that the majority of formation waters in Leonardian to Pennsylvanian-aged reservoirs consist of evaporated Late Permian seawater, which is related to the upper (Ochoan) Permian evaporites. Note that at the point of halite precipitation, geochemical modeling indicates that the estimated salinity of Late Permian seawater was 311,000 mg/L (Engle and Blondes, 2014). This value is far in excess of TDS concentrations measured in most of the samples from Guadalupian to Devonian reservoirs (Fig. 7), even though it roughly matches the δ^2H and $\delta^{18}O$ compositions of these samples. Dilution of the evaporated seawater by fresh meteoric water could have occurred but would have pushed the isotopic composition of the water off of the seawater evaporation pathway toward to the meteoric water line. A mixture of 60% Late Permian evaporated seawater concentrated by a factor of 4 times and 40% Late Permian evaporated seawater concentrated by a factor of 45 times produces roughly the same isotopic composition of water evaporated beyond the point of halite precipitation but with a much lower salinity (222,000 mg/L). This suggests that the observed composition of δ^2H and $\delta^{18}O$ and salinity of the samples represent a fairly homogeneous mixture of Late Permian seawater from different stages of evaporation, in agreement with models which call for cyclicity in the formation of evaporite deposits (Chaudhuri and Clauer, 1992).

Many of the data which plot near the composition of Late Permian seawater exhibit higher $\delta^{18}O$ values than the range of the fluid inclusion data. These same formation water samples show good agreement between their $\delta^{18}O$ values and those predicted assuming isotopic equilibrium with Wolfcampian and Pennsylvanian-age limestones in the basin (25.8–28.8‰ – Vienna Standard Mean Ocean Water basis; Saller et al., 1994) using fractionation factors based on estimated reservoir temperatures (Fig. 10). The similarity between δ^2H and $\delta^{18}O$ data for produced water samples from the "Cline" and Wolfcamp shales with those from the adjacent reservoirs also suggests that no additional source of meteoric or clay dehydration water has been added to the system, subsequently diluting the waters in the shales. Data for samples that plot outside the extent of primary fluid inclusions in Fig. 9, particularly from Guadalupian, Pennsylvanian (those that plot in the field for secondary fluid inclusions), Silurian, and Ordovician reservoirs also plot away from the trend predicted for oxygen exchange with carbonate minerals. This suggests that for these samples isotopic water–rock exchange with Paleozoic carbonate minerals is negligible.

Evidence for mixing and the origin of the fluids can be further enhanced using $^{87}Sr/^{86}Sr$ data in the produced waters and potential mineral sources of Sr. For minerals which contain abundant K (polyhalite and clays), previously developed Rb–Sr isochrons (Register and Brookins, 1980) were used to calculate the composition of these minerals during the Late Permian (252 Ma), when at least some of the fluids are thought to have formed. Nearly all of the data for samples with a suggested evaporated paleoseawater origin (Leonardian to Pennsylvanian) from the δ^2H and $\delta^{18}O$ results exhibit a narrow range of $^{87}Sr/^{86}Sr$ values (0.7085 to 0.7095), suggesting a common source. Conversely, samples which appear to be meteoric based on δ^2H and $\delta^{18}O$ results exhibit different, non-overlapping values, depending on the age of the reservoir. Such results support the hypothesis of different water sources for the fluids in

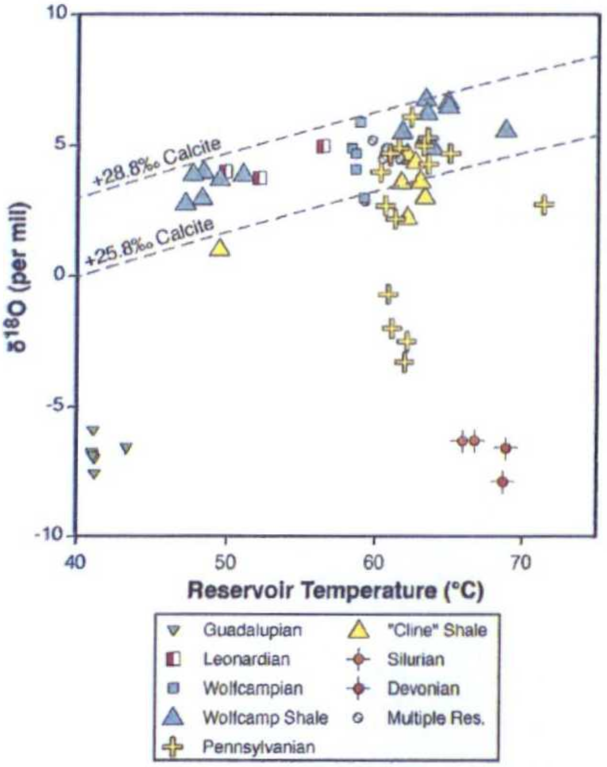


Fig. 10. Scatterplot of $\delta^{18}O$ versus estimated reservoir temperature showing the range of $\delta^{18}O$ values in isotopic equilibrium with Pennsylvanian and Wolfcampian age carbonates. Reservoir temperatures estimated using relationships between depth and corrected bottom hole temperatures in the study area using data from the Southern Methodist University National Geothermal Data System. Multiple Res. = well producing from multiple reservoirs.

Leonardian versus Devonian versus Silurian reservoirs despite all appearing to be meteoric-sourced. Based on a subset of the data presented here, Stueber et al. (1998) suggested a mixing trend between waters in the Devonian reservoirs and those in the Pennsylvanian reservoirs (Fig. 11). The linear trend on this $^{87}Sr/^{86}Sr$ versus 1/Sr plot is suggestive, but needs to be taken with caution given the limited dataset. However, this mixing would help to explain why some of the data for samples from Pennsylvanian reservoirs do not follow the predicted $\delta^{18}O$ values from isotopic exchange with Wolfcampian and Pennsylvanian limestones (Fig. 10). As an aside, use of 1/Sr concentration is not technically correct for CoDa (Blondes et al., 2015) but is still useful in identifying mixing, as it is linear in this space (mixing is non-linear in ilr transformed space).

Comparison of $^{87}Sr/^{86}Sr$ values from formation water samples with potential mineral samples in Ochoan and Guadalupian rocks (Hovorka et al., 1993; Register and Brookins, 1980) suggests that waters found in the Leonardian to Pennsylvanian reservoirs is the source of the Ochoan halite deposits across the Permian and Palo Duro Basins. This interpretation agrees with overlap of the $\delta^{18}O$ and $\delta^{2}H$ data for the same produced water samples with fluid inclusions in halite from the Palo Duro Basin (Fig. 9). The range of $^{87}Sr/^{86}Sr$ values for these formation waters and the halite + polyhalite samples (0.7085–0.7095) is far outside that of the Guadalupian anhydrite and limpid dolomite samples and of Mid- to Late-Permian seawater (0.7069–0.7076) described in the literature (Burke et al., 1982). Because there is little variance in the $^{87}Sr/^{86}Sr$ values in produced water samples from the Leonardian to Pennsylvanian reservoirs, the strontium signatures likely correspond to that of the evaporated paleoseawater when it began to sink into the basin, rather than post-infiltration water–rock reactions. One possible explanation for the radiogenic signature of the seawater in the basin during the Late Permian is that as progressive evaporation within the Permian Basin increased, moving from the Guadalupian into Ochoan Series (and thus moving from carbonate and anhydrite lithologies into halite), water flow from the west became increasingly restricted. In this scenario, radiogenic local dust inputs and sediment from arid river systems (Chaudhuri and Clauer, 1992; Register and Brookins, 1980) modified the $^{87}Sr/^{86}Sr$ values of the halite + polyhalite deposits outside of the range of bulk seawater during that period. Examination of the data for samples from Guadalupian reservoirs (which plot on the meteoric water line; Fig. 9) shows strong overlap with the Sr-bearing minerals in these units, supporting the idea that these waters have entrained most of their Sr from dissolution of these sequences. Lastly, the samples from Devonian and Silurian reservoirs (which plot on the meteoric water line; Fig. 9) show no common overlap with any of the evaporite minerals that cap the basin, suggesting that they may have been present prior to the Late Permian (Fig. 3).

Similar results are observed from the B isotopic data (Fig. 8). Formation waters from the Wolfcamp shale and Leonardian reservoirs fall in the range of predicted composition of Late Permian seawater evaporated beyond halite precipitation, although the former are slightly heavier than the latter (41.9–45.4‰ and 37.2–41.9‰, respectively). As previously discussed, waters in the "Cline" shale show additional enrichment of isotopically light B, likely derived from decomposition of marine kerogen in the shale. However, the two samples from Silurian reservoirs are distinct, exhibiting much lower $\delta^{11}B$ values of roughly 26‰. Although B isotopic data are not available for the reservoir rocks, at a reservoir temperature of 65 °C the isotopic separation (Δ) between silicate minerals and water is approximately −28‰, (Williams et al., 2001a). The corresponding $\delta^{11}B$ composition of sediments in equilibrium with these waters is roughly −2‰, which is close to the range of ancient marine sediments of −17.0 to −5.6‰ (Ishikawa and Nakamura, 1993).

Given a common origin of evaporated Late Permian seawater for brines from Leonardian to Upper Devonian reservoirs (mixture of pre- and post-halite saturation waters), processes which generated the lower salinity and high relative alkali content of formation waters from the Wolfcamp and "Cline" shale reservoirs are not obvious. Formation waters currently found in the shales likely entered after smectite to illite conversion (Fig. 3), so mechanisms other than clay diagenesis appear to be responsible. Clays act as semi-permeable membranes which limit movement of ions, particularly in the diffuse double layer near the clay–pore water interface (Magara, 1974), so diffusion of water into clay serves as one mechanism to lower salinity in formation water from shales in the Permian Basin. Laboratory and theoretical data show that for diffusion of seawater into clay, diffusion coefficients of multivalent ions are lower than those for univalent ions (Li and Gregory, 1974). Although the concentration gradient for each constituent, between the saline water in the carbonates and the less saline water originally present in the shales in the Permian Basin, is unknown, the differences between the effective diffusion coefficients for different compounds can be used to infer relative rates of diffusion. Thus,

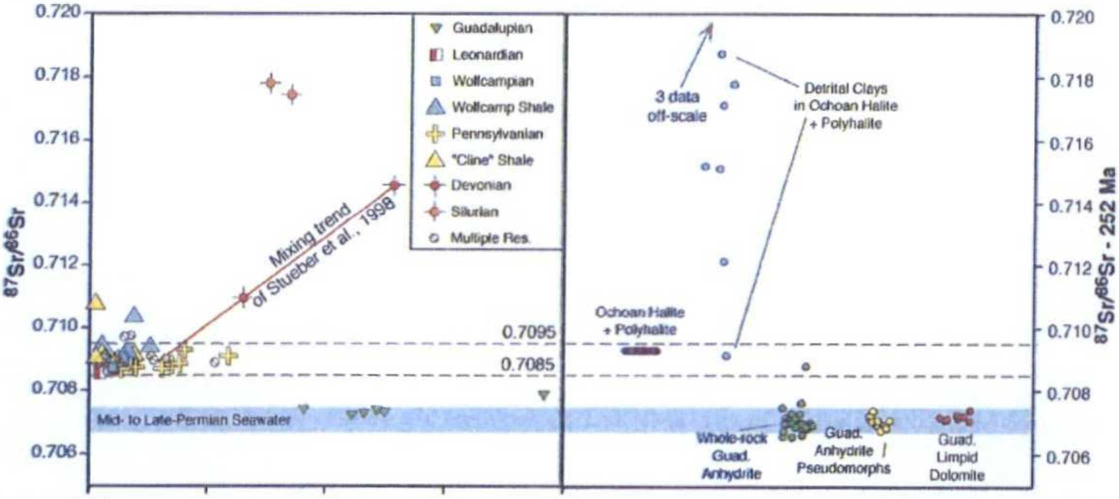


Fig. 11. Strontium isotopic data for formation water samples (left) and Ochoan and Guadalupian mineral sources (right). Random scatter along the x-axis applied to the mineral source data for each category to prevent overlapping of symbols. Data for mineral sources taken from Register and Brookins (1980) and Hovorka et al. (1993). Strontium isotopic data for Rb-bearing minerals (halite + polyhalite and detrital clays) corrected to their values during the Late Permian using the published Rb–Sr isochrons for the same samples. Estimated composition of Mid- to Late-Permian seawater taken from Burke et al. (1982). Multiple Res. = well producing from multiple reservoirs.

diffusion of solutes and water into shale reservoirs from sinking Late Permian seawater at near hydrostatic pressures (partially driven by an osmotic pressure gradient) might control shale formation water chemistry. Note, this mechanism is distinct from hyperfiltration mechanisms, which involves forcing water through clays under exceptionally high pressures. Theoretical calculations for diffusion of solutes into the Collovo-Oxfordian shale of the Paris Basin, a unit with a similar mineralogy to the Wolfcamp shale, show that effective diffusion coefficients for monovalent cations exceed those of divalent cations by up to a factor of three (Appelo et al., 2008). This limit is consistent with the results from the Permian Basin; the Na:Ca mass ratio for the geometric centers of produced waters from the Wolfcamp shale are 3.2 times higher than non-shale Wolfcampian reservoirs and the same ratio for the geometric centers for the "Cline" shale are 2.4 times higher than non-shale Pennsylvanian reservoirs. Moreover, Ca for Na ion exchange can also further increase Na/Ca ratios in clay minerals. This interpretation is also consistent with the limited boron isotope data. Although no studies on B isotope fractionation during diffusion into clays are known to exist, anions are retarded relative to neutral species in clays due to anion exclusion in the diffuse double layer (Magara, 1974). Given the affinity for ^{10}B in the borate anion, diffusion of boron would likely allow for faster transport of uncharged, ^{11}B-rich boric acid into clays producing an isotopically heavy pore water. This process might explain why δ^{11}B values for Wolfcamp shale formation water samples are slightly higher than those for Leonardian reservoirs (Fig. 8). Thus, we argue that the produced waters in the Wolfcamp and "Cline" shales are of the same origin as other fluids from Leonardian to Devonian reservoirs (evaporated Late Permian seawater), that diffused into the shales post-illitization (Fig. 3), leading to lower salinity water enriched in alkalis.

Despite low salinity fluids within the shales, salinity tends to increase with depth into Devonian reservoirs. This suggests that the dense, Late Permian seawater that sank into these deeper reservoirs, displacing less dense water previously present, was able to circumvent the low-permeability shales at the center of the basin. Large vertical structures to allow such deep fluid flow are generally absent in the basin. Platform and slope carbonates found around the basin margins (Hamlin and Baumgardner, 2012) are much more likely pathways for downward flow, allowing sinking brines to circumvent the basin-centered mudrock facies (Senger and Fogg, 1987).

Combining the various results (see Fig. 3 for summary of timing), meteoric waters found at the top and bottom of Paleozoic stratigraphic sections are separated by a nearly 1500–3000 m thick section of rock containing relatively homogenous (isotopically) Late-Permian seawater, which was mixed after evaporating to various degrees, to provide a composition with a salinity below that expected to produce halite, but with δ^2H and δ^{18}O signatures that suggest evaporation beyond halite formation. Such exceptionally dense fluids likely sunk into the basin, reacting with limestones in the Pennsylvanian and Wolfcampian reservoirs to produce the observed δ^{18}O values in some samples, at near-present reservoir temperatures. The source of meteoric water in lower salinity samples from Devonian to Ordovician rocks is unknown, although such units are part of the original Tobosa Basin, and extend for hundreds of kilometers. Pervasive karst and collapse features are found in equivalently aged Ordovician and Silurian units which outcrop near El Paso, Texas (Bellian et al., 2012), suggesting that a potential network for deep water storage and transport may exist beneath the Permian Basin. The source of the meteoric waters in the Guadalupian reservoirs is primarily thought to be derived from meteoric recharge to the west, where such units do or previously have outcropped (Barnaby et al., 2004; Bein and Dutton, 1993; Stueber et al., 1998).

4.4. Hydraulic connectivity between oil and gas reservoirs in the basin

Histograms of TDS concentrations and interpretations of isotopic data support the notion of intrusion of relatively fresh meteoric water, which gained salinity from the dissolution of evaporite minerals (Barnaby et al., 2004; Engle and Blondes, 2014; Lambert, 1992; Siegel and Anderholm, 1994) into Guadalupian and possibly Leonardian reservoirs. The bi-modal salinity of waters from Devonian reservoirs, and relatively low salinity of waters from Silurian and Ordovician reservoirs (<150 g/L) and meteoric source for those waters suggests another relatively distinct pocket of meteoric water, likely below the Woodford Shale. This deeper, chemically and isotopically distinct meteoric water is markedly different from the Late Permian seawater in overlying reservoirs, suggesting minimal communication between the two.

Histograms of in-situ pressure data from the three-county study area (Fig. 12) show differences in pressure gradients between the various reservoirs. Both Guadalupian and Leonardian reservoirs show modes (i.e., the interval with the highest frequency) that are slightly under-pressured (Fig. 12). Although some of this pattern may be related to fluid withdrawals during hydrocarbon production, under-pressuring was noted very early in the development of these fields (Elkins, 1953). Conversely, data from the Wolfcamp shale show substantial over-pressuring, consistent with its role as a source rock. Assuming maximum burial during the Eocene (Sinclair, 2007), fluid movement out of the Wolfcamp shale has been slow enough to retain some level of over-pressuring for at least 55 Ma, while allowing for under-pressuring to develop in Guadalupian and Leonardian reservoirs. Similarly, slight under-pressuring is also observed in Ordovician reservoirs, suggesting that downward fluid migration from the Wolfcamp shale and other over-pressured source rocks, has been limited (Fig. 12). Based on distinct chemical and pressure gradient differences between Late Permian seawater in Leonardian to Devonian reservoirs and meteoric waters found in older Paleozoic reservoirs, we suggest that the previously defined Deep Basin Brine Aquifer Systems of Bassett and Bentley (1982), be split into the overlying Deep Basin Brine Aquifer System and the underlying Deep Basin Meteoric Aquifer System (Fig. 2). We suggest the name for the latter to avoid confusion with paleo-meteoric water found in the Dockum and shallower portions of the basin and indicate proximity to the evaporated paleoseawater found above it.

Given a geologic history of uplift and tilting during the Laramide Orogeny and Basin and Range extension (Fig. 3), under-pressuring may have developed in more permeable layers, where eastward and southeastern flow exceeded recharge (Senger et al., 1987). In the case of Guadalupian and Leonardian reservoirs of the Permian Basin, some previous studies suggest that meteoric recharge to these reservoirs has occurred in and around the Guadalupe Mountains (Figs. 1, 4) and may be the source of meteoric waters in the same aquifers found further east into the Basin (Barnaby et al., 2004; Bein and Dutton, 1993; Stueber et al., 1998). However, more recent work in the Delaware Basin and Central Basin Platform suggests that encroachment of meteoric waters from the west is less spatially extensive in Guadalupian and Leonardian reservoirs than previously thought (Engle and Blondes, 2014). Hydrogeologic modeling of the Palo Duro Basin (Senger and Fogg, 1987) suggests that inputs from the meteoric waters sourced in New Mexico are limited in their range and that the majority of water which flow into Guadalupian and Leonardian units is through the relatively impermeable but expansive evaporite sequences. This conceptual model is also consistent with the rather uniform influx of meteoric waters across the entire basin, rather than being limited to the basin margins, and from observations of halite dissolution in several areas (Hovorka, 1998).

Within the Permian Basin, potential for upward fluid migration through natural conduits related to hydraulic fracturing of the Wolfcamp and "Cline" shales is minimal. Despite substantial over-pressuring in tight oil reservoirs, large-scale under-pressuring in Guadalupian reservoirs would greatly limit the potential for upward flow into shallower units, including drinking water reservoirs. In addition, fluid migration away from a fractured well is limited to the relatively short period between when the well is fractured (which is completed at pressures far exceeding reservoir pressures) and when the well goes into production (well pressure is set below reservoir pressure). However, this does not necessarily apply to potential transport of

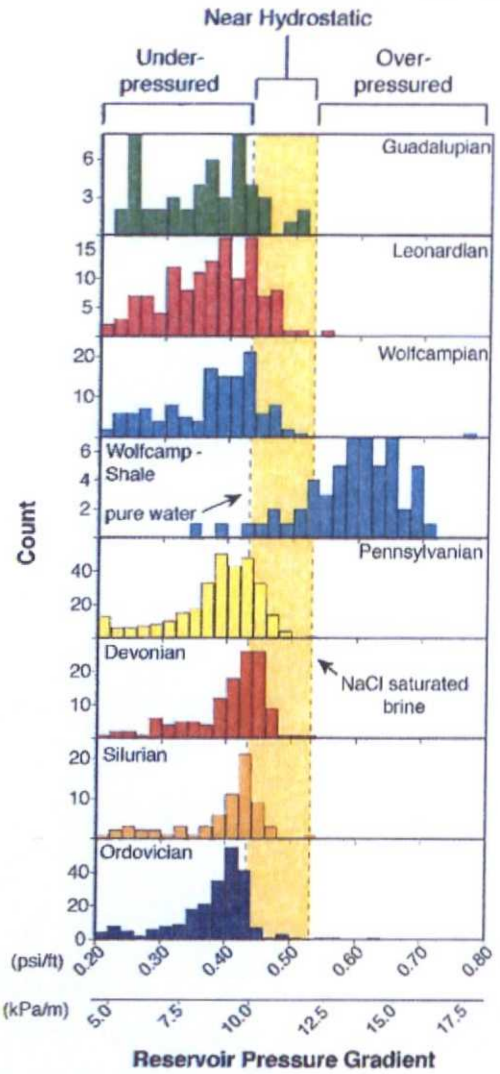


Fig. 12. Histograms showing reservoir shut-in pressure gradients from hydrocarbon reservoirs in Upton, Reagan, and Irion counties, Texas (Fig. 1).
Data taken from IHS Energy except for those for the Wolfcamp shale and a portion of the Leonardian reservoirs (Friedrich and Monson, 2013).

gas and water up well annuli, improperly abandoned wells, and other failures of infrastructure (Soeder et al., 2014; Vengosh et al., 2014).

5. Conclusions

Findings from this research examining formation waters in the eastern half of the Permian Basin suggest that during the Late Permian (Guadalupian into Ochoan), influx and mixing of evaporated seawater led to the creation of a fairly homogenous, dense volume of water, which is the original source of the evaporite minerals at the top of the Paleozoic sequence. These dense bitterns sunk down into underlying reservoirs, displacing the pre-existing fluids. The brines appear to have followed flow paths through the carbonate platforms on the basin margins, filling in permeable units around less-permeable shales and mudrocks, but were stopped above the Woodford Shale or other Devonian-age aquitards. Sulfate reduction appears to have greatly increased Ca/SO_4 ratios in these brines, and thus is partially responsible for their Ca–Cl-type composition. Sometime after smectite to illite conversion, diffusion of the paleoseawater into shales, such as the "Cline" and Wolfcamp, produced water that is isotopically indistinguishable from the source (O, H, and Sr isotopes) but has markedly lower salinity and is enriched in alkalis relative to alkaline earth elements. Release of NH_4, Br, I, and isotopically light B from marine kerogen in the "Cline" shale further modified the composition of the associated formation water. In deeper reservoirs (below the Woodford Shale), relatively old meteoric water was isolated from the overlying paleoseawater. We suggest that these two separate hydrogeologic units (previously referred to as a single hydrogeologic unit: the Deep Basin Brine Aquifer System) be split into the Deep Basin Brine Aquifer System and the underlying Deep Basin Meteoric Aquifer System, with the Woodford Shale acting as the assumed aquitard between them.

Uplift and tilting during the Laramide Orogeny and Basin and Range extension, allowed for eastward flow of formation waters in high permeability reservoirs and the development of associated under-pressuring. This led to an influx of meteoric water possibly from uplifted areas in New Mexico, but also through the expansive and low-permeability evaporites which currently cap the Paleozoic sequence. Meteoric waters, reacting with the evaporites, produce a geochemically distinct brine in Guadalupian and some of the Leonardian reservoirs. As late as the Eocene, hydrocarbons reached maximum burial allowing for over-pressuring in the shales. This over-pressuring appears to be vertically limited in the current system, indicating that vertical fluid flow via natural conduits away from the shales is constrained and would likely be stopped at overlying and underlying under-pressured reservoirs. The lack of hydraulic communication between meteoric waters in Guadalupian reservoirs and the vestigial Late Permian seawater in the Wolfcamp and "Cline" shales indicates there is little chance for meteoric waters bringing in microbes to change the composition of the hydrocarbons in the source rocks, as has occurred in shallower units.

This effort shows that characterization of formation waters from shale reservoirs, particularly in comparison to those from non-shale units of similar age, is a beneficial tool for understanding paleofluid flow and origin within basins. Moreover, the examination of vertical salinity, chemical, isotopic, and pressure gradients are proxies for potential of fluid transport between reservoirs. Reservoir connectivity has implications for both environmental impacts of unconventional hydrocarbon production as well as understanding potential movement and influx of microbe-bearing meteoric water into source rocks. For these reasons, studying vertical fluid flow in brackish aquifers which overlie hydrocarbon reservoirs is an area of research which may yield more decisive information for upward fluid potential, to complement data generated from deeper basin brines. Given interest and concern over this topic, further research on vertical fluid flow in basins is an important priority.

Disclaimer

Use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Appendix A. Supplementary data

Chemical and isotopic data for the 39 samples collected as part of this investigation, including calculated values for molar log ratio used in Figs. 5, 6, and 8. Supplementary data associated with this article can be found in the online version, at http://dx.doi.org/10.1016/j.chemgeo.2016.01.025.

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Data Bulletin

Electrical Equipment and Components in Adverse/Corrosive Environments

Class 0100

Retain for future use.

Introduction

The purpose of this bulletin is to remind users of environmental restrictions for the installation of electrical equipment and components in a corrosive environment.

Background

The installation of electrical equipment in adverse environments containing corrosive gases, liquids, or dust can cause severe and rapid deterioration of the equipment. Historically, it has been recommended to customers to keep electrical equipment free of these contaminants through the use of special enclosures or separate rooms. Furthermore, the NEC (National Electrical Code) does not provide clear direction for certain applications, such as meat rendering or water treatment facilities.

Corrosion is defined as the deterioration of a base metal resulting from a reaction with its environment. Electrical components most affected are those fabricated of copper, aluminum, and silver compounds. For good electrical contact, silver is commonly used in the contacts in circuit breakers, motor starters, and in electrical conductor plating.

Electronic components are particularly susceptible to damage by corrosive environments because of manufacturing processes and the small size of the components. Conformal coating generally used to protect printed circuit boards from dust does not protect them from corrosive gases. Frequently, the consequences of corrosion include costly unexpected down time and additional maintenance costs. Corrosion could possibly result in fire or personal injury.

For service of electrical equipment that has been exposed to water or condensation, refer to document no. 0110DB0401 titled "Water Damaged Electrical Distribution and Control Equipment."

Examples of facilities containing adverse/corrosive environments include, but are not limited to, the following:

- animal confinement areas
- meat packing plants
- rendering plants for animal products
- waste water/sewage treatment plants

Corrosive environments are also found in other operations, such as the following:

- pulp and paper processing
- oil and petroleum refining
- mining
- foundry
- chemical
- grain processing
- marine/coastal (salt) environments

EXHIBIT
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Why does it occur?

Some typical corrosive substances found in the environments in these facilities include ammonia, sulfides (especially hydrogen sulfide), sulfur dioxide, sulfates, chlorides, chlorates, methane, urea, and uric acid. These substances most frequently exist in a gaseous state or aerosol. However, some liquids are spread when the locations are washed down with high-pressure hoses and the substances are accidentally splashed onto electrical equipment.

This practice is dictated by regulation in certain industries such as food and beverage and pharmaceuticals. Corrosion is accelerated by increased concentration of contaminants, elevated temperature and high humidity. Time of exposure (in storage, in shipment, or in use) is a factor in the degree of degradation.

Table 1: Examples of Electrical Equipment and Components Affected by Typical Corrosive Environments

Predominate Corrosives	***Metals Affected***	***Equipment Affected***	***Components Affected***	
• Hydrogen Sulfide • Sulfur Dioxide and Trioxide • Ammonia • Chlorine • Chlorinated Compounds • Salts • Moisture / Water	• Copper • Silver • Tin • Aluminum • Iron and Steel • Nickel	All electrical equipment including: • Motor Control Equipment • Switchboards • Panelboards • Safety Switches • Switchgear and others	All electrical components including: • Power Monitors • Circuit Breakers • PC Boards • Bus Structures and Wiring Contactors	• Starters • Ground Fault Relays and Surge Protection Devices • PLC • Computer Equipment and others

Codes and Standards

Electrical equipment is manufactured in accordance with industry and regulatory standards for general application. A reasonably long service life can be expected when the equipment is not exposed to adverse or corrosive environments.

Few standards address the use of electrical equipment in corrosive environments. NEC 547.5 addresses the issue for agricultural buildings. Unfortunately, these buildings are often installed in locations and used under conditions in which inspection is not available or required and there is little understanding of the hazard. The installation of equipment in corrosive atmospheres is addressed in the NEC by the general statement of NEC 110.11.

Risk of Chemical Corrosion Damage

A myriad of industries use electronic and electrical control equipment to regulate various facility processes. In these industries, many plants are trying to protect this equipment from corrosive chemical pollutants. Schneider Electric representatives, in conjunction with their North American customers, have been working with third party suppliers to provide positive-pressure, airborne-contaminant free control rooms. These rooms allow for a "clean" operating environment for the electrical equipment.

Corrosion, as already discussed in the introductory section of this bulletin, may be defined as the deterioration of a metal resulting from a reaction with its environment. More specifically, it may be described as the influence of reactive gases present in an environment that cause corrosion.

Copper, silver, and gold are important materials presently used in today's industrial plant environments. The electrical performance of the equipment may be affected by the presence of corrosive gases in the local environment. Even trace levels of these gases can cause problems because of the formation of corrosion products in and on the circuitry and connectors of this equipment. Due to the nature of various manufacturing processes, it is almost a certainty that these devices will be exposed to corrosive gases.

The most effective and practical method of protecting electronic and electrical control equipment from corrosion is to remove or reduce the concentrations of corrosive gases in the environment. This reduction can be achieved by the use of gas-phase filtration equipment. Standards have been developed to define acceptable and unacceptable concentrations of corrosive gas in specific environments.

Environmental Classifications

In 1985, the Instrument Society of America (ISA) issued a standard covering the influence of airborne contaminants in electronic equipment rooms. This standard, ISA-S71.04-1985, "*Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants*" classifies different types of environments, giving acceptable gas concentration levels within these classifications.

Four levels or classes of equipment reliability, based on the level of corrosion severity, have been established by this standard.

Table 2: **Levels of Equipment Reliability**

Level	*Description*	*Equipment Reliability*
G1	Mild	Corrosion is not a factor
G2	Moderate	Effects of corrosion are measurable and may have an impact
G3	Harsh	High probability that corrosive attack will occur
GX	Severe	Only specially designed and packaged equipment could survive

These determinations were made on the basis of the measurement of the corrosion rates of oxygen-free high-conductivity copper. Corrosion is defined in terms of the corrosion film thickness that builds up on the metal after 30 days of exposure. The thickness is measured in Angstroms (Å):

Table 3: **Levels of Equipment Reliability–Corrosion to Copper**

Level	Description	Reactivity Rate
G1	Mild	0-299Å/30 days
G2	Moderate	300-999Å/30 days
G3	Harsh	1000-1999Å/30 days
GX	Severe	2000Å/30 days

While this standard has been widely accepted by major manufacturers of electronic computer equipment, there may be cases where these classifications may not provide a strict enough standard to stop corrosion of electronic equipment. In particular, the ISA standard does not address the synergistic effects of certain gases. For example, the reactivity of sulfur gases is greatly increased by just a few parts-per-billion of chlorides. Nitrogen dioxide by itself is not particularly corrosive, but when present with hydrogen sulfide, corrosion rates increase fourfold.

Summary of Control Specifications

For reference purposes, 1Å is equal to 3.94 x 10^{-9} inches.

Instrument Society of America – Standard S71.04-1985

Relative Humidity: 50%, with a rate of change of less than 6% per hour.

Corrosion Rates: Total Copper Corrosion, <300Å/30 days.

Environmental Classification Techniques

The greatest problem today is not whether these gaseous pollutant or corrosion levels can be maintained, but whether they can be accurately measured to assure compliance with any standards or control specifications.

Air Monitoring

Air monitoring is central to any environmental control program. It can provide the data required to manage and reduce pollutants in the environment. Air monitoring, along with stringent visual examination of the electrical equipment that is located in the affected environment, is a useful research method. Air monitoring is designed to determine relationships, if any, between pollutant levels and possible damaging effects to the metals used in the electrical equipment. Special modifications and protocols are often needed to adapt the monitoring instruments and methodologies for use in industrial environments.

Several characteristics of any measurement technique must be evaluated to determine its appropriateness for use in industrial air quality monitoring. Among the more important characteristics are sensitivity, cost, and complexity. Sensitivity is often a particularly demanding parameter for industrial site monitoring where low levels of many pollutants may be encountered. Likewise, cost may be quite important when deciding on a measurement technique, particularly in large surveys. A final point of consideration is the complexity of the technique and the degree of skill and training required to obtain quality results.

In addition to the outdoor pollutants requiring measurement, a variety of other parameters must be considered when assessing air quality. Among these are temperature and relative humidity which strongly affect the formation and rate of corrosion on metals.

Gas Monitoring

Gas monitoring identifies gaseous pollutants and their levels within an environment. However, it has several drawbacks. The simultaneous collection of gases which give a similar analytical response may result in measured values higher than actual concentrations. The positive interference of these gases would decrease the accuracy of the analytical technique. Alternatively, gases can interact in a way that measured values are less than concentrations actually present (negative interference). Furthermore, gas analysis can be an expensive technique and requires thorough training for implementation.

Even though it is possible to identify and quantify all chemical species one may encounter in plant and mill environments, the question still remains "What do I do with this information?" To date, there have been few published studies which provide definitive information as to the cause-and-effect relationship between levels of gaseous pollutants and the amount and type(s) of corrosion they may produce in electronic equipment. Because of this lack of information, many have turned to what is referred to as environmental classification via corrosion or reactivity monitoring. The validity for this monitoring technique lies in the fact that the control of corrosive pollutants may be the primary concern in plant and mill environments.

Atmospheric Corrosion

Atmospheric corrosion of copper has been studied extensively and tests have been devised to measure the rates of copper corrosion. These corrosion rates are currently being used to gauge electronic equipment reliability. The higher the rate of copper corrosion, the higher the probability of equipment damage and/or failure. Studies of both laboratory and field data collected by Purafil® have shown that using copper corrosion alone as a gauge for equipment reliability can seriously understate the corrosive potential of the local environment. Examination of silver corrosion data has shown instances of environments which are noncorrosive to copper but extremely corrosive to silver. Based upon this examination any testing which attempts to predict electrical/electronic equipment reliability should incorporate both copper and silver corrosion as determinants.

The reliability of electrical/ electronic equipment in corrosive environments must be accurately gauged to avoid equipment failure. It has become apparent that using a standard which employs copper-only testing is inadequate for this purpose. Field-exposed Corrosion Classification Coupons (CCCs) have shown that environments, which would be considered noncorrosive by copper–only standards, can be extremely corrosive to other functional materials. This fact was observed first on CCCs with copper and silver coupons (test strips) and, more recently, with copper, silver, and gold coupons. Laboratory testing has produced similar results and has shown that the presence or absence of certain corrosive gases affects the formation of corrosion on these metals.

The growth of various corrosion films on specially prepared copper, silver, and/or gold coupons gives an excellent indication of the type(s) and level(s) of any and all corrosive pollutants present in the local environment. Specifically developed for the classification of environments for computers and control rooms, CCCs may be used to indicate the presence of sulfur dioxide, nitrogen dioxide, hydrogen sulfide, and chlorine compounds that can cause corrosive attack on integrated circuit chips, circuit boards, relay switches, transformers, motor controls, and instrumentation systems. These corrosive attacks can lead to ghost signals, misinformation, improper process controls, and production downtime.

These CCCs normally contain copper-only or copper in combination with other metals to provide an environmental assessment. However, recent studies have shown that while copper coupons are good indicators of corrosive gases in an industrial environment, they are not sufficiently sensitive to all of the contaminants of concern in these environments.

The use of copper and silver (and gold) coupons for assessing the corrosive potential of an environment gives a more complete picture of what is actually occurring in that environment. By using the results obtained from these CCCs, one can tell what type of contaminants were present and thus can develop proper control strategies. Looking beyond copper-only environmental classifications can practically eliminate the probability of electronic equipment failure due to corrosive attack.

Atmospheric Corrosion Monitor

Those who work in the plants and mills are expected to provide and maintain well-controlled environments to prevent corrosive attack on electronic equipment. One way they do so is by continuously monitoring gaseous pollutants, temperature, and relative humidity.

Purafil® has established the shortcomings of direct gas monitoring and why the use of corrosion monitoring for environmental classification is being used as a replacement. However, corrosion coupons are not without limitations. The most important of these is the inability to provide a continuous environmental classification.

To address this issue, Purafil has developed another tool which is currently being used in plants and mills around the world. The OnGuard® 2000 Atmospheric Corrosion Monitor is the first electronic instrument which provides real-time information on the amount of corrosion occurring due to the presence of gaseous pollutants in the industrial environment. Square D/Schneider Electric Materials Technology Lab currently utilizes one of these units as an aid in helping customers determine if they have corrosive environments or if the environment has been sufficiently cleaned when existing corrosive failures have already occurred. This device monitors corrosion on a continuous basis and calculates cumulative and incremental corrosion rates. This monitoring allows for preventive action to be taken before serious damage due to chemical contamination has occurred. It also measures the temperature and relative humidity, both of which can cause increases in corrosion rates with both being important control parameters in industrial environments. Optional room pressure sensors are also available to ensure that positive pressure conditions are being maintained.

The OnGuard system may be operated by itself, using the visual information displayed on corrosion severity levels, temperature and relative humidity, or wired directly into a central computer system. By making use of the OnGuard system's ability to interface with computers, Square D/Schneider Electric customers can obtain up-to-the-minute information on these important environmental parameters. Environmental corrosion databases can be established and maintained to provide historical data to those charged with the maintenance of industrial electronic equipment. Upsets in plant operating conditions or changes that may occur in the environment during plant shutdown can also be established and a correlation can be made to any corrosive damage which may have occurred to Square D/Schneider Electric equipment.

Recommendations:

Heightened industry and construction business awareness is needed; most electrical equipment is not intended for exposure to corrosive environments. Appropriate solutions include installing electrical equipment such that it is not exposed to the corrosive environment. Factors for consideration include:

- Placement of equipment in locations away from the corrosive environment
- Selection of appropriate plating and component materials for the environment (for example: tin plating versus silver plating of copper bus bars)
- Placement of equipment inside enclosures designed for the environment
- Placement of equipment inside sealed electrical equipment rooms that are maintained with a positive pressure source of clean air

Proper selection, installation, housing, and scheduled maintenance/inspection (as recommended) of electrical equipment used in a corrosive environment will minimize the likelihood of an unexpected shutdown of the equipment, potential property damage and/or personal injury as well as costs associated with the repair or replacement of the equipment.

In summary, it is imperative to know the airborne contaminants contained in your environment prior to installing Square D/Schneider Electric Equipment as described in the table in the introductory section of this bulletin. If you suspect a corrosive environment or have questions about a possible corrosive environment in which Square D/Schneider Electric equipment is currently operating, we suggest that you contact an environmental consulting or corrosion engineering firm, such as Purafil®. These firms can determine the extent of your problem and can make recommendations for environmental remediation to include air purification and filtration.

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NACE INTERNATIONAL CORROSION 2007 CONFERENCE & EXPO

CORROSION OF ELECTRONIC CONTROL SYSTEMS IN GAS TREATING ENVIRONMENTS

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ABSTRACT

The application of microelectronic computer control systems in field locations has developed rapidly over the last 15 years. These distributed control systems (DCS) are far more prone to corrosion damage than earlier control systems. Of particular concern are locations where sulfur species may be present such as hydrogen sulfide, sulfur dioxide, or elemental sulfur. Failures of critical components may occur in as little as three months in locations where humidity, temperature, and corrosive gasses are not adequately controlled. Temporary relief may be obtained by the use of vapor phase corrosion inhibitor (VCI) powders and sprays.* A more permanent solution is the installation and maintenance of an adequate air handling system that removes pollutants and controls humidity and temperature. This paper reports a number of different failures that occurred in one plant including general corrosion of circuit boards and a history module and corrosion fatigue of copper conductor wires on an electronics circuit board. Field data on different solutions to the problem are presented.

* Cortec VpCI-238, VpCI-111 Emitters

EXHIBIT
FF

INTRODUCTION

Conventional analogue control systems used in the oil and gas processing industry have been somewhat insensitive to corrosion. Relatively heavy wall thicknesses of component parts compared to modern day microelectronic circuits meant that some minor corrosion could be tolerated with no significant detriment. Therefore, many years of satisfactory service could be obtained in older control rooms that had some air treatment but were not pressurized control rooms with sophisticated air handling systems. The thickness of electrical connectors on microelectronic distributed control system (DCS) circuit boards is much less, meaning that even the smallest amount of corrosion can cause board failure.

Although the importance of industrial corrosive atmospheres has been well recognized in some industries such as pulp and paper for some time,[1] only recently has its significance become more prevalent in the oil and gas industry. In the past, central control rooms may have been the only places equipped with temperature and environmental control systems; now a broader range of buildings such as remote process interface buildings must also be included. Field mounted control systems must be hermetically sealed to prevent ingress of corrosive atmospheres. In uncomplicated processing plants, even the central control room may not have adequate control systems. Conversion of older plants from conventional control systems to modern DCS systems can be a challenge. The scope of the project must include adequate funding to upgrade air handling systems.

Air quality is defined in the Instrument Society of America Standard ISA-S71.04-1985. A non-corrosive environment is described as G1 and is expected to contain less than

Gas	Concentration, ppb
H_2S	<3
SO_2 / SO_3	<10
Cl_2	<1
NO_x	<50

Table 1: ISA G1 requirements for specific gases

The provision of a G1 environment will result in corrosion having no significant effect on the life of circuit boards. In all the lesser categories, G2, G3, and GX, corrosion has an increasingly devastating effect.

Surveys of atmospheric corrosivity over a number of gas plants and refineries have found the most corrosive areas to be associated with sulfur handling areas and areas with H_2S and SO_2 emissions. In Kuwait, a broader study of atmospheric corrosion over most of the country found the highest atmospheric corrosion rates of copper to be associated with oil and gas producing areas, as shown in Figure 1.[2]

FAILURES OF HISTORY MODULE AND MONITORS

A series of repetitive failures occurred in various parts of the control system at a sulfur handling plant. Sulfur handling is the last part of the gas treating process. Hydrogen sulfide is removed from the sales gas in an amine unit and the resultant waste gases are fed to a Claus sulfur unit, followed by the sulfur pelletizer. Failures were reported in the sulfur peletizer plant's main control room components such as visual display monitors, printers, radios, and similar electronic equipment. Failures were also reported in the adjacent room that housed electronic racks, known as the LCN cabinet room, and marshalling area. In the cabinet room, the History Module was of great concern because failure times were as short as three months. The Communications Module also failed in approximately two years. Two separate lines of investigation were followed: an evaluation of the failed components and an evaluation of the atmosphere in the locations where the failure occurred.

Failure Analysis

The History Modules external electronic circuit board was badly affected by atmospheric corrosion caused by ingress of sulfur species from the plant. Electrical failure was attributed to corrosion by sulfur species.

Visual and stereomicroscope examination showed that many circuit board pads and connectors were badly tarnished (Figures 2, 3). Though heavy copper sulfide (Cu_2S) corrosion products were present on many conductor tracks and pads, the circuit board's gold-plated external connector pins were not corroded (Figure 3). The hard drive's vacuum seal was still intact. Further laboratory investigation of the problem included microscopy and energy dispersive microanalysis (EDS) of extracted corrosion products, which were removed using a replication technique.

Optical microscopy of the electronic module revealed radial growth of iridescent brown-black deposits on open connector pads (Figure 4). The deposits formed from corrosion of copper in a sulfur-bearing environment. These deposits appeared to be growing out from beneath the connector holes and coalescing with time, perhaps leading to a short circuit of related electronic components. The corrosion products were extracted onto acetate replica tape. EDS microanalysis (Figure 5) revealed primarily copper (Cu) and sulfur (S) in the corrosion products, corresponding to copper sulfide (Cu_2S).

Although the exact corrosive species were not identified in this part of the investigation, it is noted, for example, that wet elemental sulfur can be very corrosive to steels[2]. One proposed mechanism for steel corrosion is that elemental sulfur and distilled water can react to produce H_2S and sulfuric acid, to give a pH as low as 1.8. Although there was no direct evidence of sulfate corrosion products on the circuit board, even humidity and moisture can produce undesirable effects in electronics, such as causing electrical shorts and changes in electrical resistance[3].

Atmospheric Classification

Coupon tests were performed using copper, silver, and gold-plated coupon sets that provide copper corrosion product film growth data in accordance with Instrument Society of America classification ISA S71.04-1985.

This classification rates the corrosivity of the environment in four categories: mild, moderate, harsh, or severe. Mild or "G1" environments are usually specified for control rooms and DCS systems. In such an environment, no corrosion failures are expected. Moderate or "G2" environments predict that premature failure *may* occur in under five years. Harsh or "G3" environments expect that corrosion failures *will* occur in five years or less. Severe or "GX" environments are likely to cause rapid failure of electronic systems.

The coupon set also provides corrosion product film growth data for silver coupons. Silver coupons are more sensitive to low levels of contaminants and are particularly affected by sulfur compounds. The silver coupons are not formally addressed by the ISA standard.

The coupon set also provides a visual evaluation of gold plating damage.

In the current set of experiments, coupon sets were placed on top of a monitor in the control room and on top of the cabinets in the cabinet room, and on top of cabinets in a newly constructed sub-station. Coupons were exposed for 92 days.

The control room and cabinet room was found to be extremely corrosive. The copper corrosion product film thickness was rated moderately corrosive, G2. The silver corrosion rate was equivalent to severe, GX. The cabinet room adjacent to the control room, was rated as harsh, G3, with respect to copper corrosion and silver corrosion. Figure 6 shows the cabinet room coupons.

Examination of mechanical air-handling equipment at the site found that there was no effective pressurization of the area. There was no chemical absorption of corrosive gases. There was only the most rudimentary control particulate matter and humidity.

Trials with VpCI Sprays

An experiment was performed with a temporary preservative to investigate the possibility of the obtaining some interim protection and provide an opportunity for the air handling system to be upgraded. The temporary preservative used was a thin film corrosion inhibitor with a vapor phase component that can be sprayed onto electronic components. An additional coupon set was sprayed with a temporary preservative, and placed on top of the monitor in the control room.

The silver corrosion product film thickness was reduced by a factor of fifteen from 3245Å (Angstroms = 10^{-8}m) to 217Å. The copper corrosion product film thickness was reduced from 610Å to 191Å, a factor of three. Figure 7 presents the coupon set.

	Copper Film Thickness Angstroms (10^{-8}m)	Silver Film Thickness Angstroms (10^{-8}m)	Copper Classification	Silver Classification
Without Inhibitor	610	3,245	G2	GX
With Inhibitor	191	217	G1	G1

Table 2: Effect of VpCI Spray

Benefits of a Well Designed Air Handling System

The atmospheric corrosion rates experienced in a newly constructed, adjacent substation were completely different from those experienced in the rest of the plant. The atmosphere was rated non-corrosive. Both copper and silver corrosion rates were classed as mild, G1, *indicating that corrosion should not be an issue for this building, providing* that the air conditioning system is adequately monitored and maintained. Figure 8 shows the coupons.

The measurements made in the newly constructed substation building clearly demonstrate the benefits of an air handling system designed to control contaminants and reduce humidity. The air-handling system with a coarse particulate filter, a fine bag filter system, chemical absorbents, and air conditioning to reduce humidity resulted in a G1 atmosphere. Nevertheless, it is also important to point out that the exact design of the air treatment system will affect the results. Light duty systems have thinner absorbent beds meaning that media changes must be performed much more frequently and periods of "breakthrough" are thereby increased. Heavier duty systems provide much more stable conditions and are more effective at removal of contaminants.

For effective corrosion control, the humidity must be reduced to less than 50 percent relative humidity. Pollutants such as sulfur compounds must be greatly reduced.

Maintenance and Continuous Monitoring Required

Over time, this absorbent will be consumed and need to be replaced with new absorbent to be effective again. The manufacturer's guidelines on the absorbent packs for this particular system design in this plant are that the media should be replaced every 6 to 24 months. This is a very general recommendation. It is therefore essential that on-line corrosion monitoring equipment be used to accurately determine when the media must be replaced. While grab-sample analysis of media beds may be used, such measurements can generate misleading data as consumption of the bed occurs progressively from the entry side of the bed, rather than uniformly throughout the bed. Therefore, results can vary greatly depending upon where exactly the sampling grab is taken. Corrosion monitoring equipment for electronic systems is available from a selection of vendors. Coupons can also be used for monitoring, but these require placement, retrieval and processing, which impedes the feedback of information. Some media vendors market tools to provide feedback on consumption of media using specially designed tools that can be withdrawn and reinserted in the bed.

CORROSION FATIGUE FAILURE[4]

Corrosion failures of electronic equipment also occurred in sealed field units at the same plant. The corrosive atmosphere migrated inside the sealed housing, and multiple repetitive failures resulted. The corrosive species involved in these failures were also sulfur compounds. The result was corrosion fatigue of copper conductor wires on an electronics circuit board. Time to failure was approximately one year. Following detailed evaluation, the failure mode of the transformer's copper conductor leads was confirmed to be corrosion fatigue. Vibration plus sulfur corrosion had promoted the transgranular fatigue cracking and some fine, secondary corrosion fatigue cracks were also found.

Failure Analysis

Several failed boards, showing transformer lead breaks, were examined (Figure 9). The fractures of these leads were studied on-site with a hand lens, which revealed that the leads showed a low ductility failure mode. Some leads and lead fractures were discolored, in some cases virtually blackened, and this was suspected to be a superficial corrosion product. Although the service life of these boards was not known precisely, an upper estimate was derived from the circuit board manufacturing date codes, found on the reverse side of the boards. More than ten failures have occurred, and failure after as little as about a year in service is strongly suspected.

The transformer lead wires had broken at a position close to the transformer coil (Figure 10). The blue arrows on the plan view of the four boards indicate the locations of the five broken transformer leads. Figure 10 shows a side view of one of the two broken leads on board 2; its location is marked on Figure 9. Several lead fractures were examined in the scanning electron microscope (SEM). The fracture surfaces of the all leads showed low ductility, flat fractures which were tarnished or blackened (Figure 11). After ultrasonic cleaning, two lead fractures (from boards 2 and 4) were examined at increasing magnifications. At 2000x magnification, a very flat fracture surface was apparent, with a hint of fatigue striations.

The lead failures were flat and non-ductile and showed characteristics of fatigue fracture at both a low and high magnification examination. Following fracture examination, longitudinal microsections were taken along the failed wires to include the fracture surfaces. Evidence of fine secondary microcracks was also found (Figure 12); these tiny cracks contained a dark-colored corrosion product. The microsection showed that the leads are made from tinned copper wire; the copper was fine grained and annealed. Finally, two blackened lead fracture surfaces were examined using a 15 kV electron gun potential in the SEM, to get an improved surface microanalysis. This clearly revealed that the corrosion product film comprised copper and sulfur, presumably as copper sulfide.

Following laboratory evaluation and a site visit, the failure mode of the transformer's copper conductor leads was indicated to be corrosion fatigue. Vibration plus corrosion by sulfur compounds had promoted the fatigue cracking and some fine, secondary corrosion fatigue cracks were also found.

Although the switch circuit board housing is sealed with an O-ring, sulfur ingress had caused corrosion on some component leads. By design, the pelletizer plant experiences significant vibration during unit operation, via the reciprocating motion of the shaker screen beneath the pelletizer hopper tank.

The lead failures occurred by vibration-induced fatigue damage, which was accelerated by sulfur corrosion. The exact corrosion mechanism and species is uncertain, although sulfide corrosion in electronics is often caused by ingress of gaseous hydrogen sulfide and failures have occurred below the odor threshold[5]. Although the circuit board housing was intentionally sealed with an O-ring, sulfur ingress presumably occurred from the process, possibly via the conduit thread. Two particular risk environments promoting sulfide corrosion have been reported to exist[5]: (1) from an external industrial source; (2) hydrogen sulfide generated by out-gassing or decomposition of organic materials containing sulfur, which can include seals or gaskets, depending upon the elastomers used. This article[5] also noted that: "Copper and silver are widely used in electronics because of their excellent electrical and thermal properties. Unfortunately both have very low activation energies towards the formation of sulfides with hydrogen sulfide. The sulfide corrosion product is porous so hydrogen sulfide continues to reach the metal surface. As long as the gas is present there is no mechanism to stop the corrosion process. In contrast tin, another metal commonly used in electronic assembly, forms an impervious sulfide layer, which prevents further reaction." Since the subject transformer copper wires were tinned, this may therefore have offered some initial protection. Once cracks started growing by fatigue, the thin tin layer would have been breached, leading to bare copper exposure to the corrosive sulfur environment.

The following recommendations are possible options to alleviate the problem of corrosion and fatigue:

1. Mount the electronics remotely.
2. Consider a more rugged construction, where the manufacturer encapsulates the circuit board in a resin, to minimize mechanical and other forms of damage, such as corrosion. A field alternative is to use a polymer spray on the boards to minimize corrosion, such as the vapor phase corrosion inhibitor spray tested in the control rooms discussed in the previous section.
3. Minimize or dampen the vibrations. Although vibration is inherent in this process, stiffening the hopper tank with ribs, etc., may effectively reduce the mechanical vibrations and modify any resonance.
4. Improve sealing of the housing to eliminate ingress of the corrosive atmosphere.

CONCLUSIONS

The expanding use of electronic control systems in potential corrosive plant environments requires detailed design of adequate corrosion control measures to avoid the liability of high downtime costs due to the failure of relatively small system components.

Two different series of failures have been discussed. The first involves the failures of component electronic boards in various control room systems due to inadequate control of the room environment. In this case, corrosion control can be achieved by temporary techniques such as the application of vapor phase corrosion inhibitors, applied as a spray coating specially formulated for electronic boards or more permanently, by the installation and maintenance of an adequate air handling system that includes fine particulate removal, chemical absorbance, and humidity control. The second series of failures involves the corrosion fatigue failure of board components for a remote field mounted control system. In this case failure can be prevented by reducing vibration, and eliminating the corrosive environment through the use of temporary VCI sprays, or the use of encapsulated circuit boards, or the use of more effective case seals.

Detailed analyses of several upstream and downstream oil and gas plants have found the most corrosive atmospheres are found in the waste gas treatment area, and in particular in the sulfur handling area.

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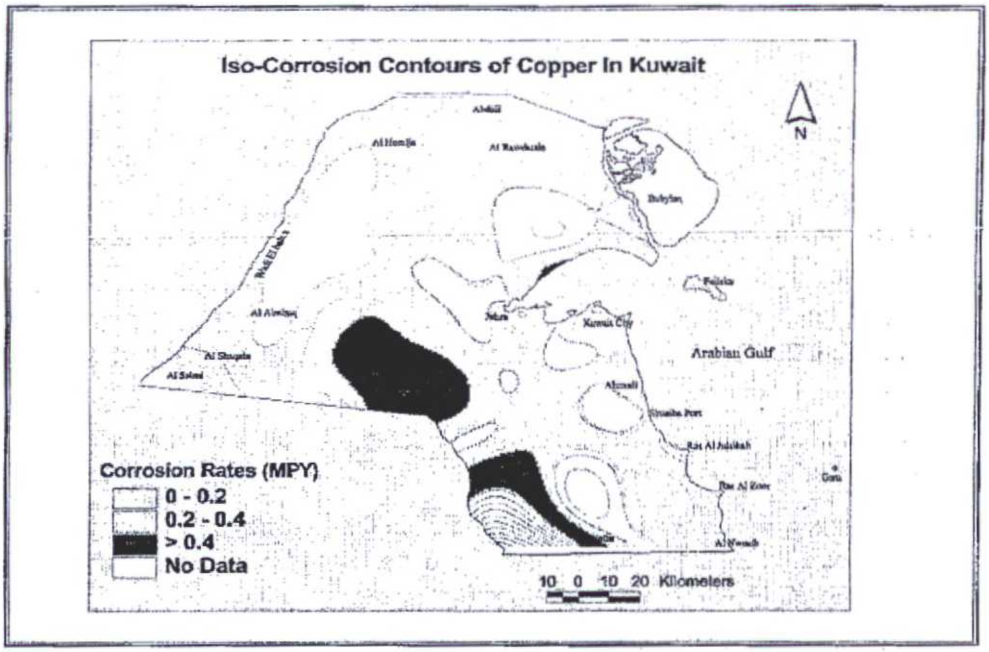

Figure 1: Atmospheric corrosion data for copper in Kuwait[2]

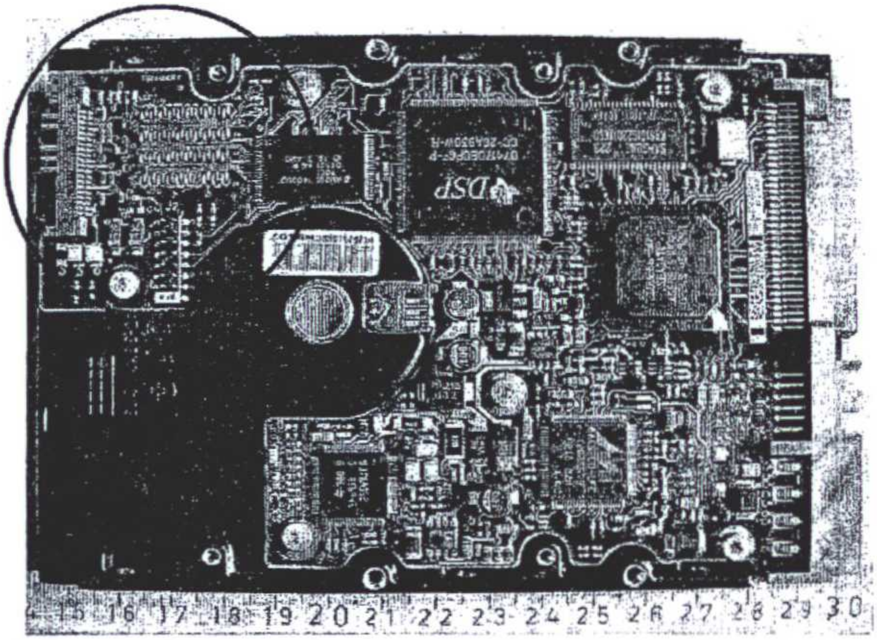

Figure 2: View of the module circuit board, after removal of external covers.

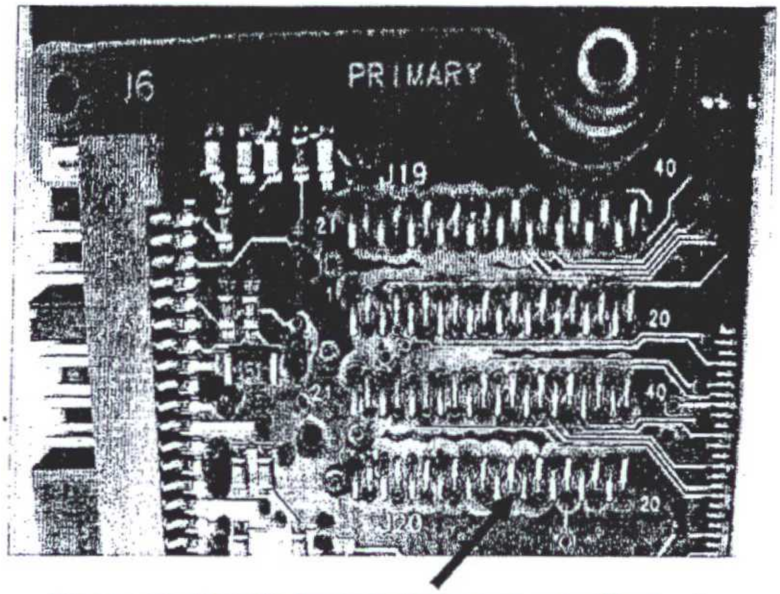

Figure 3: Detail view of circled area in Figure 1.
Note corroded pads (arrow) and uncorroded external contact pins (left)

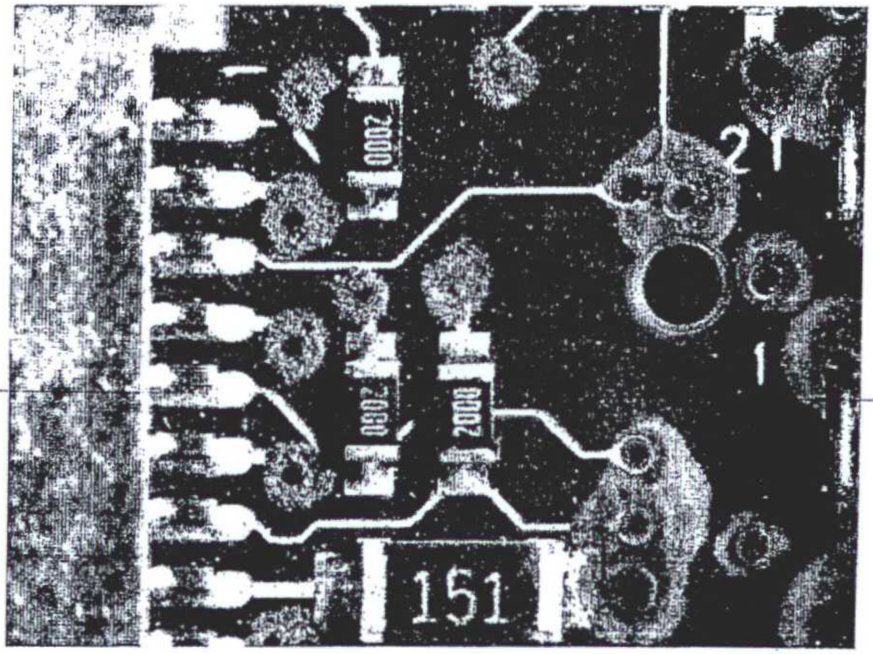

Figure 4: Optical image of corrosion product

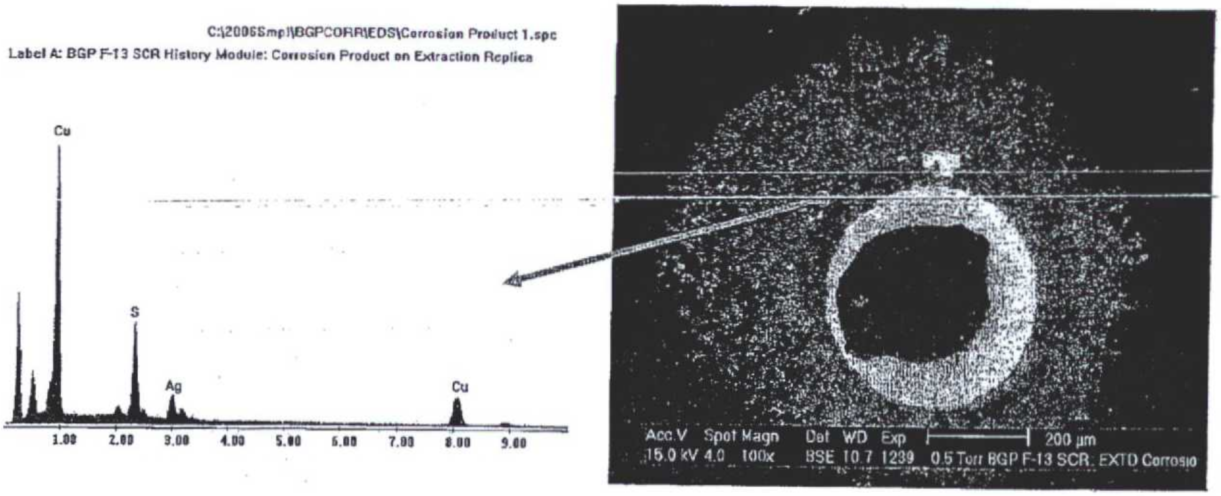

Figure 5: EDS X-ray microanalysis spectrum of corrosion product and corresponding BSE image in the scanning electron microscope

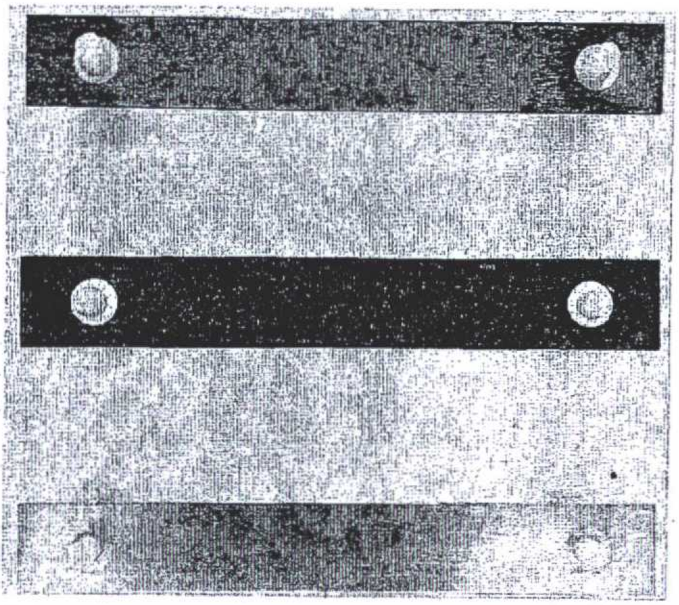

Figure 6: Cabinet room results

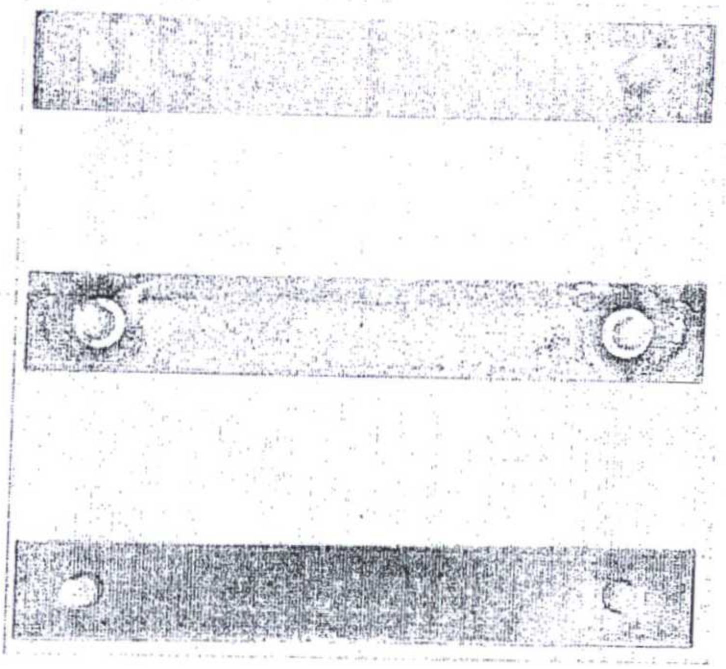

Figure 7: Control room exposure with inhibitor

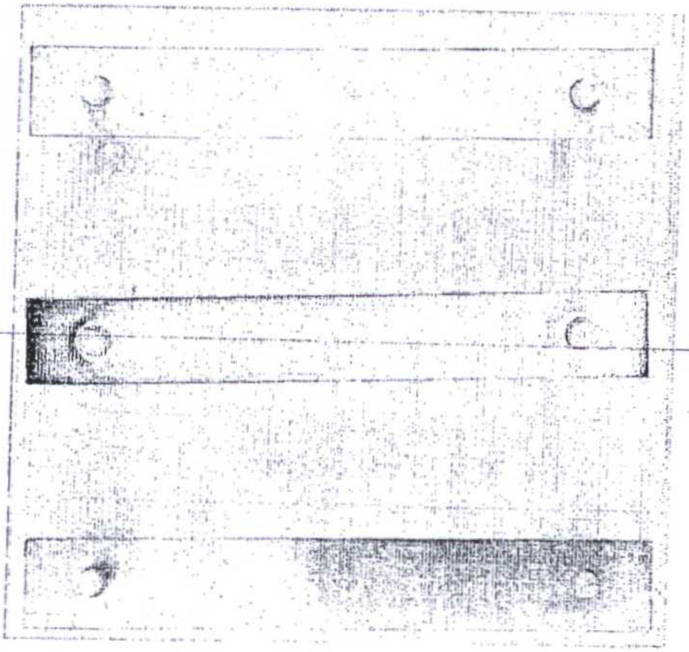

Figure 8: Newly constructed substation results

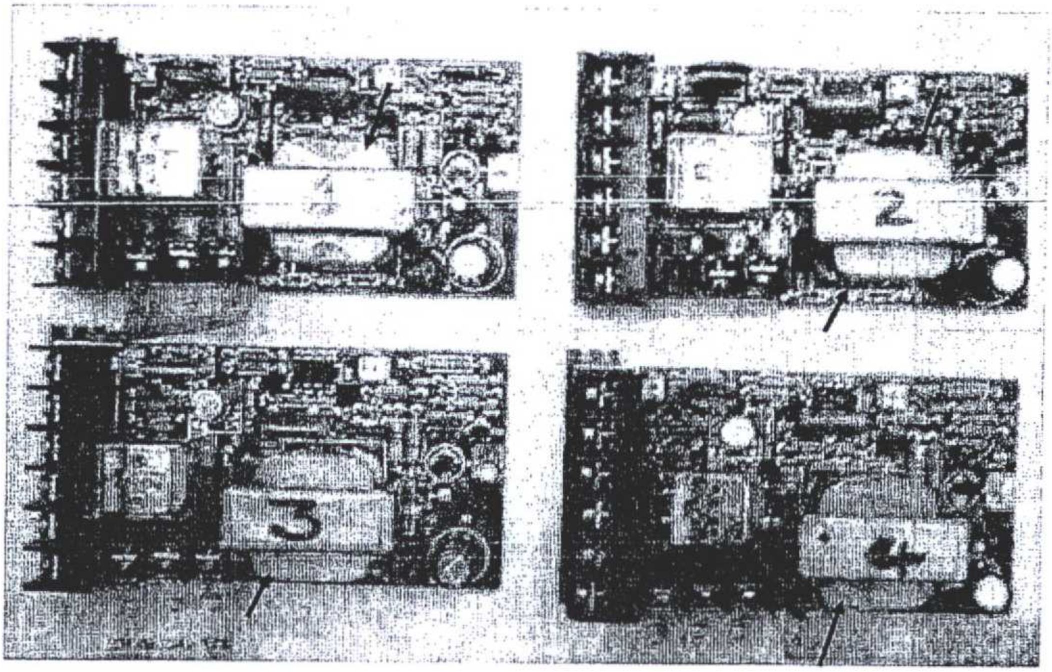

Figure 9: Plan view of four circuit boards, as received; arrows show locations of transformer lead failures.

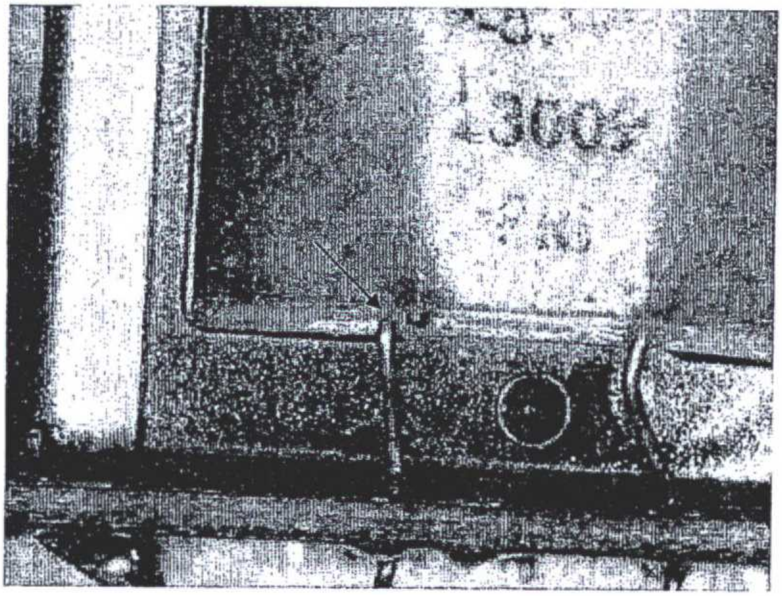

Figure 11: Side view of a broken transformer lead on Board # 2 (arrow), magnification approximately 2X

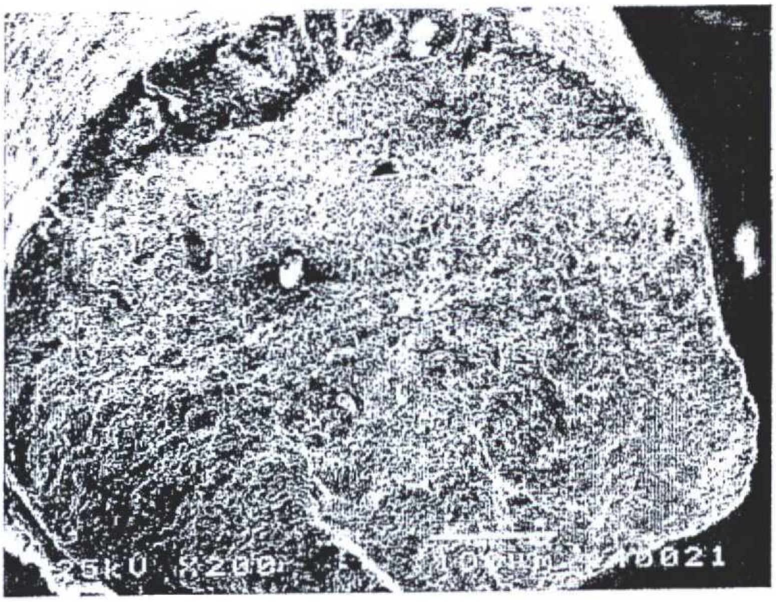

Figure 11: Fracture surface of broken lead, Board # 2
SEM micrograph, 200X

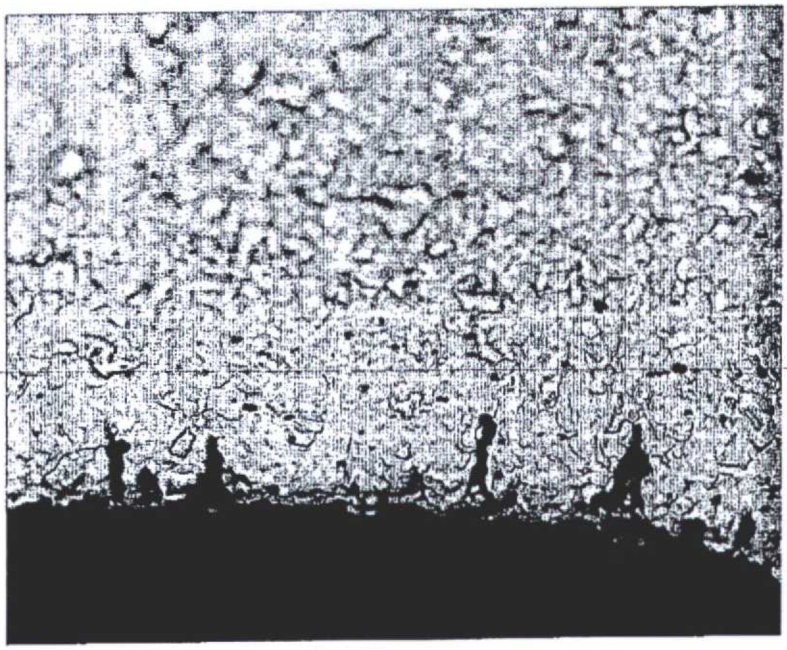

Figure 12: Microsection showing fine secondary cracks on broken transformer lead from Board # 2, etched 750X

PART 3
AMBIENT AIR QUALITY STANDARDS

20.2.3.1 ISSUING AGENCY:
Environmental Improvement Board.
[11/30/95; 20.2.3.1 NMAC - Rn, 20 NMAC 2.3.100 10/31/02]

20.2.3.2 SCOPE:
All geographic areas within the jurisdiction of the Environmental Improvement Board.
[11/30/95; 20.2.3.2 NMAC - Rn, 20 NMAC 2.3.101 10/31/02]

20.2.3.3 STATUTORY AUTHORITY:
Environmental Improvement Act, NMSA 1978, section 74-1-8(A)(4) and Air Quality Control Act, NMSA 1978, sections 74-2-1 et seq., including specifically, section 74-2-5(A) and (B).
[11/30/95; 20.2.3.2 NMAC - Rn, 20 NMAC 2.3.102 10/31/02]

20.2.3.4 DURATION:
Permanent.
[11/30/95; 20.2.3.4 NMAC - Rn, 20 NMAC 2.3.103 10/31/02]

20.2.3.5 EFFECTIVE DATE:
November 30, 1995.
[11/30/95; 20.2.3.5 NMAC - Rn, 20 NMAC 2.3.104 10/31/02]
[The latest effective date of any section in this Part is 9/6/06.]

20.2.3.6 OBJECTIVE:
The objective of this Part is to establish ambient air quality standards for the areas of New Mexico under the jurisdiction of the Environmental Improvement Board.
[11/30/95; 20.2.3.6 NMAC - Rn, 20 NMAC 2.3.105 10/31/02]

20.2.3.7 DEFINITIONS:
In addition to the terms defined in 20.2.2 NMAC (Definitions), as used in this Part:" Part" means an air quality control regulation under Title 20, Chapter 2 of the New Mexico Administrative Code, unless otherwise noted; as adopted or amended by the Board.
[11/30/95; 20.2.3.7 NMAC - Rn, 20 NMAC 2.3.107 10/31/02]

20.2.3.8 AMENDMENT AND SUPERSESSION OF PRIOR REGULATIONS:
This Part amends and supersedes Air Quality Control Regulations ("AQCR") 200 - Preamble and 201 - Ambient Air Quality Standards last filed January 27, 1970 and June 15, 1981, respectively.

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A. All references to AQCR 200 or 201 in any other rule shall be construed as a reference to this Part.

B. The amendment and supersession of AQCR 200 and 201 shall not affect any administrative or judicial enforcement action pending on the effective date of such amendment nor the validity of any permit issued pursuant to AQCR 200 or 201.

[11/30/95; 20.2.3.8 NMAC - Rn, 20 NMAC 2.3.106 10/31/02]

20.2.3.9 LIMITATION OF APPLICABILITY TO 20. 2.70 NMAC. The requirements of this part are not applicable requirements under 20.2.70 NMAC, as defined by that part. This section does not limit the applicability of this part to sources required to obtain a permit under 20.2.72 NMAC, nor does it limit which terms and conditions of permits issued pursuant to 20.2.72 NMAC are applicable requirements for permits issued pursuant to 20.2.70 NMAC.

[20.2.3.9 NMAC - N, 9/6/06]

20.2.3.10 to 20.2.3.107 [RESERVED]

20.2.3.108 PREAMBLE:

Ambient Air Quality Standards are not intended to provide a sharp dividing line between air of satisfactory quality and air of unsatisfactory quality. They are, however, numbers which represent objectives that will preserve our air resources. It is understood that at certain times, due to unusual meteorological conditions, these standards may be exceeded for short periods of time without the addition of specific pollutants into the atmosphere. The adoption of these statewide ambient air quality standards does not prohibit the promulgation of standards for specific areas, functions, and conditions within the state such as air sheds, municipalities, and certain counties, as authorized under the Act. As scientific data accumulates on the effects of a contaminant, these standards may be revised or additional standards added.

[11/30/95; 20.2.3.108 NMAC - Rn, 20 NMAC 2.3.108 10/31/02]

20.2.3.109 TOTAL SUSPENDED PARTICULATES:

The maximum allowable concentrations of total suspended particulate in the ambient air are as follows:

A.	24-hour average:	150 ug/m3;
B.	7-day average:	110 ug/m3;
C.	30-day average:	90 ug/m3;
D.	Annual geometric mean:	60 ug/m3.

[11/30/95; 20.2.3.109 NMAC - Rn, 20 NMAC 2.3.109 10/31/02]

20.2.3.110 SULFUR COMPOUNDS:

The maximum allowable concentrations of the following sulfur-containing air contaminants in the ambient air are as follows:

A. Sulfur Dioxide:

(1) For the state except on the area within 3.5 miles of the Chino Mines Company smelter furnace stack at Hurley:

(a) 24-hour average: 0.10 ppm;
(b) Annual arithmetic average: 0.02 ppm;

(2) For the area within 3.5 miles of the Chino Mines Company smelter furnace stack at Hurley:

(a) 24-hour average, not be exceeded more than once per year: 0.14 ppm;
(b) 3-hour average, not to be exceeded more than once per year: 0.50 ppm;
(c) Annual arithmetic average: 0.03 ppm.

B. Hydrogen Sulfide:

(1) For the state, except the Pecos-Permian Basin Intrastate Air Quality Control Region (1-hour average, not to be exceeded more than once per year): 0.010 ppm;

(2) For the Pecos-Permian Basin Intrastate Air Quality Control Region (1/2 hour average): 0.100 ppm;

(3) For within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region (1/2 hour average): 0.030 ppm;

(4) For within five miles of the corporate limits of municipalities having a population of greater than twenty thousand and within the Pecos-Permian Basin Intrastate Air Quality Control Region (1/2 hour average): 0.030 ppm.

C. Total Reduced Sulfur:

(1) For the state, except the Pecos-Permian Basin Intrastate Air Quality Control Region except for hydrogen sulfide (1/2 hour average): 0.003 ppm;

(2) For the Pecos-Permian Basin Intrastate Air Quality Control Region, except for hydrogen sulfide (1/2 hour average): 0.010 ppm;

(3) For within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for hydrogen sulfide (1/2 hour average): 0.003 ppm;

(4) For within five miles of the corporate limits of municipalities having a population of greater than twenty thousand and within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for hydrogen sulfide (1/2 hour average): 0.003 ppm.

[11/30/95; 20.2.3.110 NMAC - Rn, 20 NMAC 2.3.110 10/31/02]

20.2.3.111 OTHER AIR CONTAMINANTS:

The maximum allowable concentrations of the following air contaminants in the ambient air are as follows:

A. Carbon Monoxide:

(1) 8-hour average: 8.7 ppm;
(2) 1-hour average: 13.1 ppm;

B. Nitrogen Dioxide:

(1) 24-hour average: 0.10 ppm;
(2) Annual arithmetic average: 0.05 ppm.

[11/30/95; 20.2.3.111 NMAC - Rn, 20 NMAC 2.3.111 10/31/02]

HISTORY OF 20.2.3 NMAC:

Pre-NMAC History: *The material in this part was derived from that previously filed with the* commission of public records-state records center and archives:

HSSD 70-1, Ambient Air Quality Standards And Air Quality Control Regulations, 01/27/70.
EIB/AQCR 201, Ambient Air Quality Standards, 12/07/79.
AQCR 201, Ambient Air Quality Standards, 06/15/81.

History of Repealed Material: [RESERVED]

Other History:
AQCR 201, Ambient Air Quality Standards, filed 06/15/81 was **renumbered** into first version of the New Mexico Administrative Code as 20 NMAC 2.3, Air Quality (Statewide) - Ambient Air Quality Standards, filed 10/30/95.
20 NMAC 2.3, Air Quality (Statewide) - Ambient Air Quality Standards, filed 10/30/95 was **renumbered, reformatted and replaced** by 20.2.3 NMAC, Ambient Air Quality Standards, effective 10/31/02.

PART 2
DEFINITIONS

20.2.2.1 ISSUING AGENCY:
New Mexico Environmental Improvement Board.
[10/27/95; 20.2.2.1 NMAC - Rn, 20 NMAC 2.100, 10/31/02]

20.2.2.2 SCOPE:
The provisions of this part shall apply to all New Mexico regulations regarding air quality, and codified as 20.2.3 NMAC through 20.2.99 NMAC.
[10/27/95; 20.2.2.2 NMAC - Rn, 20 NMAC 2.101, 10/31/02]

20.2.2.3 STATUTORY AUTHORITY:
The environmental improvement board "shall promulgate regulations and standards in ... air quality management" (NMSA 1978, section 74-1-8.A) and "the Environmental Improvement Board... shall adopt... regulations to attain and maintain national ambient air quality standards and prevent or abate air pollution..." (NMSA 1978, section 74-2-5.B).
[10/27/95; 20.2.2.3 NMAC - Rn, 20 NMAC 2.102, 10/31/02]

20.2.2.4 DURATION:
Permanent.
[10/27/95; 20.2.2.4 NMAC - Rn, 20 NMAC 2.103, 10/31/02]

20.2.2.5 EFFECTIVE DATE:
October 27, 1995.
[10/27/95; 20.2.2.5 NMAC - Rn, 20 NMAC 2.104, 10/31/02]
[The latest effective date of any section in this Part is 08/31/09.]

20.2.2.6 OBJECTIVE:
To provide specific definitions for terms used and not defined in air quality regulations 20.2.3 NMAC through 20.2.99 NMAC.
[10/27/95; 20.2.2.6 NMAC - Rn, 20 NMAC 2.105, 10/31/02]

20.2.2.7 DEFINITIONS:
The following definitions apply to all Parts of Title 20, Chapter 2 NMAC.

A. **"Administrator"** means the administrator of the United States environmental protection agency (US EPA) or his or her designee.

B. **"Aerodynamic diameter"** means the diameter of a sphere of unit density which behaves aerodynamically the same as the particle of the test substance. It is used to predict where particles of different size and density may be deposited in the respiratory tract.

C. **"Air contaminant"** means any airborne substance, including but not limited to, any particulate matter, fly ash, dust, fumes, gas, mist, smoke, vapor, micro-organisms, radioactive material, any combination thereof or any decay or reaction product thereof.

D. **"Air pollution"** means the emission, except as such emission occurs in nature, into the outdoor atmosphere of one or more air contaminants in such quantities and duration as may with reasonable probability injure human health, animal or plant life, or as may unreasonable interfere with the public welfare, visibility or the reasonable use of property.

E. **"Asbestos"** includes chrysolite, crocidolite, amosite, anthophylite, tremolite, and actinolite.

F. **"Board"** means the New Mexico environmental improvement board or its successor agency or authority.

G. **"Carbon dioxide"** means the chemical compound containing one atom of carbon and two atoms of oxygen.

H. **"Carbon monoxide"** means the chemical compound containing one atom of carbon and one atom of oxygen.

I. **"Department"** means the New Mexico environment department or its successor agency or authority, as represented by the department secretary or his or her designee.

J. **"Federal act"** means the Federal Clean Air Act, as amended, 42 U.S.C. sections 7401 et seq.

K. **"Flue"** means, any duct for air, gases, or the like, such as a stack or chimney.

L. **"Fugitive dust"** or **"fugitive particulate matter"** means particulate emissions which escape to the atmosphere due to leakage; materials handling, transfer or storage; travel over unpaved roads or parking areas; or other industrial activities, and which are not ducted through exhaust systems.

M. **"Greenhouse gas"** means any of the following: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons or sulfur hexafluoride.

N. **"Heavy metal"** means any metal having an atomic number greater than 21.

O. **"Hydrofluorocarbons"** means gaseous chemical compounds containing only hydrogen, carbon, and fluorine atoms.

P. **"Hydrogen sulfide"** means the chemical compound containing two atoms of hydrogen and one atom of sulfur.

Q. **"Kraft pulp"** means the fibrous cellulose material produced in a kraft mill.

R. **"Lead"** means elemental lead; alloys in which one of the elements is lead; or compounds containing lead, which are measured as elemental lead.

S. **"Methane"** means the chemical compound containing one atom of carbon and four atoms of hydrogen.

T. **"mg/m3"** means milligrams per cubic meter.

U. **"Nitrogen dioxide"** means the chemical compound containing one atom of nitrogen and two atoms of oxygen, for the purposes of ambient determinations. The term "nitrogen dioxide," for the purposes of stack emissions monitoring, shall include nitrogen dioxide (the chemical compound containing one atom of nitrogen and two atoms of oxygen), nitric oxide (the chemical compound containing one atom of nitrogen and one atom of oxygen), and other oxides of nitrogen which may test as nitrogen dioxide.

V. **"Nitrous oxide"** means the chemical compound containing two atoms of nitrogen and one atom of oxygen.

W. **"Non-methane hydrocarbons"** means any combination of hydrocarbons (chemical compounds consisting of hydrogen and carbon) excluding only the molecule methane.

X. **"Ozone"** means the chemical compound having the molecular composition of three oxygen atoms.

Y. **"Particulate matter"** means any airborne, finely divided solid or liquid material with an aerodynamic diameter smaller than 100 micrometers.

Z. **"Particulate matter emissions"** means all finely divided solid or liquid material, other than uncombined water, emitted to the ambient air as measured by: applicable reference methods; an equivalent or alternative method specified by the administrator; or a test method specified in the New Mexico state implementation plan.

AA. **"Perfluorocarbons"** means gaseous chemical compounds containing only carbon and fluorine atoms.

AB. **"Person"** means any individual; partnership; corporation; association; municipality; the state or political subdivision of the state; and any agency, department, or instrumentality of the United States and any of their officers, agents, or employees.

AC. **"Photochemical oxidents"** means those oxidizing chemical compounds which are the products of photo initiated reactions involving organic compounds and nitrogen oxides, consisting primarily of ozone and peroxyacetyl nitrate (PAN).

AD. **"PM10"** means particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers.

AE. **"PM10 emissions"** means finely divided solid or liquid material with an aerodynamic diameter less than or equal to a nominal 10 micrometers, emitted to the ambient air, as measured by: an applicable reference method; an equivalent or alternative method specified by the EPA administrator; or a test method specified in the New Mexico state implementation plan.

AF. **"PM2.5"** means particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers.

AG. **"PM2.5 emissions"** means finely divided solid or liquid material with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers, emitted to the ambient air, as measured by: an applicable reference method; an equivalent or alternative method specified by the EPA administrator; or a test method specified in the New Mexico state implementation plan.

AH. **"ppm"** means parts per million by volume.

AI. **"Ringelmann scale"** means the grading of opacity, appearance, density or shade of a smoke emission, in determining the light-obscuring power of smoke.

AJ. **"Schedule of compliance"** means a schedule or timetable, acceptable to the board, which clearly sets out in detail, the steps to be taken in achieving the objectives of a regulation or standard.

AK. **"Secretary"** means the secretary of the New Mexico environment department or his or her designee.

AL. **"Smoke"** means small gas-borne particles resulting from incomplete combustion, consisting predominantly, by not exclusively, of carbon, soot and combustible material.

AM. **"Sulfur dioxide"** means the chemical compound containing one atom of sulfur and two atoms of oxygen, for the purposes of ambient determinations. The term sulfur dioxide, for the purposes of stack emissions monitoring, shall include sulfur dioxide (chemical compound containing one atom of sulfur and two atoms of oxygen), and other oxides of sulfur which may test as sulfur dioxide.

AN. **"Sulfur hexafluoride"** means the chemical compound containing one atom of sulfur and six atoms of fluorine.

AO. **"Total reduced sulfur"** means any combination of sulfur compounds, except sulfur dioxide and free sulfur, which test as total reduced sulfur, including, but not limited to, hydrogen sulfide, methyl mercaptan, and ethyl mercaptan.

AP. **"Total suspended particulates (TSP)"** means particulate matter as measured by the method described in 40 CFR Part 50, Appendix B.

AQ. **"ug/m3"** means micrograms per cubic meter.

AR. **"US EPA"** means the United States environmental protection agency.

AS. **"Volatile organic compound (VOC)"** means any organic compound which participates in atmospheric photochemical reactions; that is, any organic compound other than those which the administrator designates as having negligible photochemical reactivity.

[10/27/95; 20.2.2.7 NMAC - Rn, 20 NMAC 2.2.200 10/31/02; A, 01/01/08; A, 08/31/09]

20.2.2.8 AMENDMENT AND SUPERSESSION OF PRIOR REGULATIONS:
This part supersedes AQCR 100, originally filed on January 23, 1970, and subsequently amended and refiled on May 26, 1971, September 1, 1971, September 14, 1973, June 14, 1974, July 15, 1974, February 7, 1983, May 26, 1983, August 1, 1988, and May 29, 1990.

[10/27/95; 20.2.2.8 NMAC - Rn, 20 NMAC 2.2.106, 10/31/02]

20.2.2.9 DOCUMENTS:
Documents cited in this part may be viewed at the New Mexico Environment Department, Air Quality Bureau, Runnels Building, 1190 Saint Francis Drive, Santa Fe, NM 87503 [2048 Galisteo St., Santa Fe, NM 87505].

[10/27/95; 20.2.2.9 NMAC - Rn, 20 NMAC 2.2.107, 10/31/02]

HISTORY OF 20.2.2 NMAC:

Pre-NMAC History: The material in this part was derived from that previously filed with the commission of public records-state records center and archives:
HSSD 70-1, Ambient Air Quality Standards and Air Quality Control Regulations, 01/27/70.
AQCR 100, Air Quality Control Regulation 100 - Definitions, 02/07/83.
AQCR 100, Air Quality Control Regulation 100 - Definitions, 05/26/83.
EIB/AQCR 100, Air Quality Control Regulation 100 - Definitions, 08/01/88.
EIB/AQCR 100, Air Quality Control Regulation 100 - Definitions, 05/29/90.

History of Repealed Material: [RESERVED]

Other History:
EIB/AQCR 100, Air Quality Control Regulation 100 - Definitions, filed 05/29/90 was **renumbered** into first version of the New Mexico Administrative Code as 20 NMAC 2.2, Definitions, effective 10/27/95.
20 NMAC 2.2, Definitions (filed 09/27/95) was **renumbered, reformatted and replaced** by 20.2.2 NMAC, Definitions, effective 10/31/02.

PART 70
OPERATING PERMITS

20.2.70.1 ISSUING AGENCY:
Environmental Improvement Board.
[11/30/95; 20.2.70.1 NMAC - Rn, 20 NMAC 20.2.70.100 06/14/02]

20.2.70.2 SCOPE:
All persons who own or operate a major source or any other source required to obtain a permit under this Part.
[11/30/95; 20.2.70.2 NMAC - Rn, 20 NMAC 20.2.70.101 06/14/02]

20.2.70.3 STATUTORY AUTHORITY:
Environmental Improvement Act, NMSA 1978, section 74-1-8(A)(4) and (7), and Air Quality Control Act, NMSA 1978, sections 74-2-1 et seq., including specifically, section 74-2-5(A), (B), and (C) and (D).
[11/30/95; 20.2.70.3 NMAC - Rn, 20 NMAC 20.2.70.102 06/14/02]

20.2.70.4 DURATION:
Permanent.
[11/30/95; 20.2.70.4 NMAC - Rn, 20 NMAC 20.2.70.103 06/14/02]

20.2.70.5 EFFECTIVE DATE:
11/30/95, except where a later date is cited at the end of a section.
[11/30/95; 20.2.70.5 NMAC - Rn, 20 NMAC 20.2.70.I.104, 06/14/02; A, 9/6/06]
[The latest effective date of any section in this part is 8/1/2008.]

20.2.70.6 OBJECTIVE:
The objective of this Part is to establish the requirements for obtaining an operating permit.
[11/30/95; 20.2.70.6 NMAC - Rn, 20 NMAC 20.2.70.105 06/14/02]

20.2.70.7 DEFINITIONS:
In addition to the terms defined in 20.2.2 NMAC (definitions), as used in this part the following definitions shall apply.

A. **"Acid rain source"** has the meaning given to "affected source" in the regulations promulgated under Title IV of the federal act, and includes all sources subject to Title IV of the federal act.

B. **"Affected programs"** means all states, local air pollution control programs, and Indian tribes and pueblos, that are within 50 miles of the source.

C. **"Air pollutant"** means an air pollution agent or combination of such agents, including

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any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the administrator has identified such precursor or precursors for the particular purpose for which the term "air pollutant" is used. This excludes water vapor, nitrogen (N2), oxygen (O2), and ethane.

D. **"Air pollution control equipment"** means any device, equipment, process or combination thereof, the operation of which would limit, capture, reduce, confine, or otherwise control regulated air pollutants or convert for the purposes of control any regulated air pollutant to another form, another chemical or another physical state. This includes, but is not limited to, sulfur recovery units, acid plants, baghouses, precipitators, scrubbers, cyclones, water sprays, enclosures, catalytic converters, and steam or water injection.

E. **"Applicable requirement"** means all of the following, as they apply to a Part 70 source or to an emissions unit at a Part 70 source (including requirements that have been promulgated or approved by the board or US EPA through rulemaking at the time of permit issuance but have future-effective compliance dates).

(1) Any standard or other requirement provided for in the New Mexico state implementation plan approved by US EPA, or promulgated by US EPA through rulemaking, under Title I of the federal act to implement the relevant requirements of the federal act, including any revisions to that plan promulgated in 40 CFR, Part 52.

(2) Any term or condition of any preconstruction permit issued pursuant to regulations approved or promulgated through rulemaking under Title I, including Parts C or D, of the federal act, unless that term or condition is determined by the department to be no longer pertinent.

(3) Any standard or other requirement under Section 111 of the federal act, including Section 111(d).

(4) Any standard or other requirement under Section 112 of the federal act, including any requirement concerning accident prevention under Section 112(r)(7) of the federal act.

(5) Any standard or other requirement of the acid rain program under Title IV of the federal act or the regulations promulgated thereunder.

(6) Any requirements established pursuant to Section 504(b) or Section 114(a)(3) of the federal act.

(7) Any standard or other requirement governing solid waste incineration under Section 129 of the federal act.

(8) Any standard or other requirement for consumer and commercial products under Section 183(e) of the federal act.

(9) Any standard or other requirement for tank vessels under Section 183(f) of the federal act.

(10) Any standard or other requirement of the regulations promulgated to protect stratospheric ozone under Title VI of the federal act, unless the administrator has determined that such requirements need not be contained in a Title V permit.

(11) Any national ambient air quality standard.

(12) Any increment or visibility requirement under Part C of Title I of the federal act, but only as it would apply to temporary sources permitted pursuant to Section 504(e) of the federal act.

(13) Any regulation adopted by the board pursuant to the New Mexico Air Quality Control Act, Section 74-2-5(B) NMSA 1978.

F. **"CFR"** means the Code of Federal Regulations.

G. **"Draft permit"** means a version of a permit which the department offers for public participation or affected program review.

H. **"Emission limitation"** means a requirement established by US EPA, the board, or the department, that limits the quantity, rate or concentration, or combination thereof, of emissions of regulated air pollutants on a continuous basis, including any requirements relating to the operation or maintenance of a source to assure continuous reduction.

I. **"Emissions allowable under the permit"** means:

(1) any state or federally enforceable permit term or condition that establishes an emission limit (including a work practice standard) requested by the applicant and approved by the department or determined at issuance or renewal to be required by an applicable requirement; or

(2) any federally enforceable emissions cap that the permittee has assumed to avoid an applicable requirement to which the source would otherwise be subject.

J. **"Emissions unit"** means any part or activity of a stationary source that emits or has the potential to emit any regulated air pollutant or any air pollutant listed pursuant to Section 112(b) of the federal act. This term is not meant to alter or affect the definition of the term "unit" for purposes of Title IV of the federal act.

K. **Federally enforceable"** means all limitations and conditions which are enforceable by the administrator, including those requirements developed pursuant to 40 CFR Parts 60 and 61, requirements within the New Mexico state implementation plan, and any permit requirements established pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR Part 51, Subpart I, including 40 CFR 51.165 and 40 CFR 51.166.

L. **"Final permit"** means the version of an operating permit issued by the department that has met all review requirements of 20.2.70.400 NMAC - 20.2.70.499 NMAC.

M. **"Fugitive emissions"** are those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening.

N. **"General permit"** means an operating permit that meets the requirements of 20.2.70.303 NMAC.

O. **"Greenhouse gas"** for the purpose of this part is defined as the aggregate group of the following six gases: carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

P. **"Hazardous air pollutant"** means an air contaminant that has been classified as a hazardous air pollutant pursuant to the federal act.

Q. **"Insignificant activities"** means those activities which have been listed by the department and approved by the administrator as insignificant on the basis of size, emissions or production rate.

R. **"Major source"** means any stationary source (or any group of stationary sources that are located on one or more contiguous or adjacent properties, and are under common control of the same person(s)) in which all of the pollutant emitting activities at such source belong to the same major group (i.e., all have the same two-digit code), as described in the standard industrial classification manual, 1987, and that is described in Paragraphs (1), (2) or (3) below.

(1) A major source under Section 112 of the federal act, which is defined as the following.

(a) For pollutants other than radionuclides, any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit, in the aggregate, 10 tons or more per year of any hazardous air pollutant which has been listed pursuant to Section 112 (b) of the federal act, 25 or more tons per year of any combination of such hazardous air pollutants (including any major source of fugitive emissions of any such pollutant, as determined by rule by the administrator), or such lesser quantity as the administrator may establish by rule. Notwithstanding the preceding sentence, hazardous emissions from any oil or gas exploration or production well (with its associated equipment) and hazardous emissions from any pipeline compressor or pump station shall not be aggregated with hazardous emissions from other similar units, whether or not such units are in a contiguous area or under common control, to determine whether such units or stations are major sources.

(b) For radionuclides, "major source" shall have the meaning specified by the administrator by rule.

(2) A major stationary source of air pollutants that directly emits or has the potential to emit, 100 or more tons per year of any air pollutant subject to regulation (including any major source of fugitive emissions of any such pollutant, as determined by rule by the administrator). The fugitive emissions of a stationary source shall not be considered in determining whether it is a major stationary source for the purposes of this paragraph, unless the source belongs to one of the following categories of stationary sources:

(a) coal cleaning plants (with thermal dryers);
(b) kraft pulp mills;
(c) portland cement plants;
(d) primary zinc smelters;
(e) iron and steel mills;
(f) primary aluminum ore reduction plants;
(g) primary copper smelters;
(h) municipal incinerators capable of charging more than 250 tons of refuse per day;
(i) hydrofluoric, sulfuric, or nitric acid plants;
(j) petroleum refineries;
(k) lime plants;
(l) phosphate rock processing plants;
(m) coke oven batteries;
(n) sulfur recovery plants;
(o) carbon black plants (furnace process);
(p) primary lead smelters;
(q) fuel conversion plant;
(r) sintering plants;
(s) secondary metal production plants;
(t) chemical process plants;
(u) fossil-fuel boilers (or combination thereof) totaling more than 250 million British thermal units per hour heat input;
(v) petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels;
(w) taconite ore processing plants;
(x) glass fiber processing plants;
(y) charcoal production plants;
(z) fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;
(aa) any other stationary source category, which as of August 7, 1980 is being regulated under Section 111 or 112 of the federal act.

(3) A major stationary source as defined in Part D of Title I of the federal act, including:

(a) for ozone non-attainment areas, sources with the potential to emit 100 tons or more per year of volatile organic compounds or nitrogen oxides in areas classified as "marginal" or "moderate," 50 tons or more per year in areas classified as "serious," 25 tons or more per year in areas classified as "severe," and 10 tons or more per year in areas classified as "extreme"; except that the references in this paragraph to 100, 50, 25, and 10 tons per year of nitrogen oxides shall not apply with respect to any source for which the administrator has made a finding, under Section 182(f)(1) or (2) of the federal act, that requirements under Section 182(f) of the federal act do not apply;

(b) for ozone transport regions established pursuant to Section 184 of the federal act, sources with the potential to emit 50 tons or more per year of volatile organic compounds;

(c) for carbon monoxide non-attainment areas (1) that are classified as "serious," and (2) in which stationary sources contribute significantly to carbon monoxide levels as determined under rules issued by the administrator, sources with the potential to emit 50 tons or more per year of carbon monoxide; and

(d) for particulate matter (PM10) non-attainment areas classified as "serious," sources with the potential to emit 70 tons or more per year of PM10.

S. **"Operating permit"** or **"permit"** (unless the context suggests otherwise) means any permit or group of permits covering a source that is issued, renewed, modified or revised pursuant to this part.

T. **"Operator"** means the person or persons responsible for the overall operation of a facility.

U. **"Owner"** means the person or persons who own a facility or part of a facility.

V. **"Part"** means an air quality control regulation under Title 20, Chapter 2 of the New Mexico Administrative Code, unless otherwise noted; as adopted or amended by the board.

W. **"Part 70 source"** means any source subject to the permitting requirements of this part, as provided in 20.2.70.200 NMAC - 20.2.70.299 NMAC.

X. **"Permit modification"** means a revision to an operating permit that meets the requirements of significant permit modifications, minor permit modifications, or administrative permit amendments, as defined in 20.2.70.404 NMAC.

Y. **"Permittee"** means the owner, operator or responsible official at a permitted Part 70 source, as identified in any permit application or modification.

Z. **"Portable source"** means any plant that is mounted on any chassis or skids and which can be moved by the application of a lifting or pulling force. In addition, there shall be no cable, chain, turnbuckle, bolt or other means (except electrical connections) by which any piece of equipment is attached or clamped to any anchor, slab, or structure, including bedrock, that must be removed prior to the application of a lifting or pulling force for the purpose of transporting the unit. Portable sources may include sand and gravel plants, rock crushers, asphalt plants and concrete batch plants which meet this criteria.

AA. **"Potential to emit"** means the maximum capacity of a stationary source to emit any air pollutant under its physical and operational design. Any physical or operational limitation on the capacity of a source to emit an air pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation is federally enforceable. The potential to emit for nitrogen dioxide shall be based on total oxides of nitrogen.

AB. **"Proposed permit"** means the version of a permit that the department proposes to issue and forwards to the administrator for review in compliance with 20.2.70.402 NMAC.

AC. **"Regulated air pollutant"** means the following:

(1) nitrogen oxides, total suspended particulate matter, or any volatile organic compounds;

(2) any pollutant for which a national ambient air quality standard has been promulgated;

(3) any pollutant that is subject to any standard promulgated under Section 111 of the federal act;

(4) any class I or II substance subject to any standard promulgated under or established by Title VI of the federal act;

(5) any pollutant subject to a standard promulgated under Section 112 or any other requirements established under Section 112 of the federal act, including Sections 112(g), (j), and (r), including the following;

(a) any pollutant subject to requirements under Section 112(j) of the federal act; if the administrator fails to promulgate a standard by the date established pursuant to Section 112(e) of the federal act, any pollutant for which a subject source would be a major shall be considered to be regulated on the date 18 months after the applicable date established pursuant to Section 112(e) of the federal act; and

(b) any pollutant for which the requirements of Section 112(g)(2) of the federal act have been met, but only with respect to the individual source subject to a Section 112(g)(2) requirement; or

(6) any other pollutant subject to regulation as defined in Subsection AL of this section.

AD. **"Renewal"** means the process by which a permit is reissued at the end of its term.

AE. **"Responsible official"** means one of the following.

(1) For a corporation: a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation, or a duly authorized representative of such person if the representative is responsible for the overall operation of one or more manufacturing, production, or operating facilities applying for or subject to a permit and either a) the facilities employ more than 250 persons or have gross annual sales or expenditures exceeding $25 million (in second quarter 1980 dollars), or b) the delegation of authority to such representative is approved in advance by the department.

(2) For a partnership or sole proprietorship: a general partner or the proprietor, respectively.

(3) For a municipality, state, federal or other public agency: either a principal executive officer or ranking elected official. For the purposes of this part, a principal executive officer of a federal agency includes the chief executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., a regional administrator of US EPA).

(4) For an acid rain source: the designated representative (as defined in Section 402(26) of the federal act) in so far as actions, standards, requirements, or prohibitions under Title IV of the federal act or the regulations promulgated thereunder are concerned, and for any other purposes under 40 CFR, Part 70.

AF. **"Section 502(b)(10) changes"** are changes that contravene an express permit term. Such changes do not include changes that would violate applicable requirements or contravene permit terms and conditions that are monitoring (including test methods), recordkeeping, reporting, or compliance certification requirements.

AG. **"Shutdown"** means the cessation of operation of any air pollution control equipment, process equipment or process for any purpose.

AH. **"Solid waste incineration unit"** means a distinct operating unit of any facility which combusts any solid waste material from commercial or industrial establishments or the general public (including single and multiple residences, hotels, and motels). The term "solid waste incineration unit" *does not include:*

(1) incinerators or other units required to have a permit under Section 3005 of the federal Solid Waste Disposal Act;

(2) materials recovery facilities (including primary or secondary smelters) which combust waste for the primary purpose of recovering metals;

(3) qualifying small power production facilities, as defined in Section 3(17)(C) of the Federal Power Act (16 U.S.C. 796(17)(C)), or qualifying cogeneration facilities, as defined in Section 3(18)(B) of the Federal Power Act (16 U.S.C. 796(18)(B)), which burn homogeneous waste (such as units which burn tires or used oil, but not including refuse-derived fuel) for the production of electric energy or in the case of qualifying cogeneration facilities which burn homogeneous waste for the production of electric energy and steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating or cooling purposes; or

(4) air curtain incinerators, provided that such incinerators only burn wood wastes, yard wastes and clean lumber and that such air curtain incinerators comply with opacity limitations established by the administrator by rule.

AI. **"Startup"** *means the setting into operation of any air pollution control equipment,* process equipment or process for any purpose.

AJ. **"Stationary source"** or "source" means any building, structure, facility, or installation, or any combination thereof that emits or may emit any regulated air pollutant or any pollutant listed under Section 112(b) of the federal act.

AK. **"Subsidiary"** means a business concern which is owned or controlled by, or is a partner of, the applicant or permittee.

AL. **"Subject to regulation"** means, for any air pollutant, that the pollutant is subject to either a provision in the act, or a nationally-applicable regulation codified by the administrator in subchapter C of 40 CFR Chapter I, that requires actual control of the quantity of emissions of that pollutant, and that such a control requirement has taken effect and is operative to control, limit or restrict the quantity of emissions of that pollutant released from the regulated activity. Except that:

(1) "greenhouse gases" (GHGs) shall not be subject to regulation, unless, as of July 1, 2011, the GHG emissions are at a stationary source emitting or having the potential to emit 100,000 tons per year CO_2e equivalent emissions;

(2) the term "tons per year CO_2e equivalent emissions" (CO_2e) shall represent the aggregate amount of GHGs emitted by the regulated activity, and shall be computed by multiplying the mass amount of emissions (tons per year), for each of the six greenhouse gases in the pollutant GHGs, by the gas's associated global warming potential published at Table A-1 to subpart A of 40 CFR part 98 - Global Warming Potentials, and summing the resultant value for each gas; for purposes of this paragraph, prior to July 21, 2014, the mass of the greenhouse gas carbon dioxide shall not include carbon dioxide emissions resulting from the combustion or decomposition of non-fossilized and biodegradable organic material *originating from plants, animals, or micro-organisms* (including products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material);

(3) if a federal court stays, invalidates or otherwise renders unenforceable by the US EPA, in whole or in part, the prevention of significant deterioration and Title V greenhouse gas tailoring rule (75 FR 31514, June 3, 2010), the definition "subject to regulation" shall be enforceable by the department only to the extent that it is enforceable by US EPA.

AM. **"Temporary source"** means any plant that is situated in one location for a period of less than one year, after which it will be dismantled and removed from its current site or relocated to a new site. A temporary source may be semi-permanent, which means that is does not have to meet the requirements of a portable source. Temporary sources may include well head compressors which meet this criteria.

AN. **"Title I modification"** means any modification under Sections 111 or 112 of the federal act and any physical change or change in method of operations that is subject to the preconstruction regulations promulgated under Parts C and D of the federal act.

[11/30/95; 20.2.70.7 NMAC - Rn, 20 NMAC 2.70.I.107, 06/14/02; A, 11/07/02; A, 09/06/06; A, 01/01/11; A, 02/06/13]

20.2.70.8 AMENDMENT AND SUPERSESSION OF PRIOR REGULATIONS:

This Part amends and supersedes Air Quality Control Regulation ("AQCR") 770, - Operating Permits, filed November 15, 1993, as amended ("AQCR 770"). The original effective date of AQCR 770 was December 19, 1994, which was the effective date of approval, by the Administrator, of the New Mexico operating permit program. (See 59 FR 59656, November 18, 1994).

A. All references to AQCR 770 in any other rule shall be construed as a reference to this Part.

B. The amendment and supersession of AQCR 770 shall not affect any administrative or judicial enforcement action pending on the effective date of such amendment nor the validity of any permit issued pursuant to AQCR 770.

[11/30/95; 20.2.70.8 NMAC - Rn, 20 NMAC 2.70.106 06/14/02]

20.2.70.9 DOCUMENTS:

Documents cited in this Part may be viewed at the New Mexico Environment Department, Air Quality Bureau, Runnels Building, 1190 Saint Francis Drive, Santa Fe, NM 87505 [1301 Siler Rd., Bldg. B, Santa Fe, NM 87507].

[11/30/95; 20.2.70.9 NMAC - Rn, 20 NMAC 2.70.108 06/14/02; A, 01/01/11]

20.2.70.10 to 20.2.70.199 [RESERVED]

20.2.70.200 PART 70 SOURCES:

Operating permits must be obtained from the Department for the following sources:

A. Any major source;

B. Any source, including an area source, subject to a standard or other requirement promulgated under section 111 -- Standards of Performance for New Stationary Sources, or section 112 -- Hazardous Air Pollutants, of the Federal Act, but not including any source which:

(1) is exempted under subsection B of 20.2.70.202 NMAC; or

(2) would be required to obtain a permit solely because it is subject to regulations or requirements under section 112(r) of the Federal Act;

C. Any acid rain source; and

D. *Any source in a source category so designated by the Administrator, in whole or in part,* by regulation, after notice and comment.
[11/30/95; 20.2.70.200 NMAC - Rn, 20 NMAC 2.70.200 06/14/02]

20.2.70.201 REQUIREMENT FOR A PERMIT:

A. A Part 70 source may operate after the time that it is required to submit a timely and complete application under this part only if:

(1) the source is in compliance with an operating permit issued by the department or EPA; or

(2) a timely permit (including permit renewal) application has been submitted consistent with 20.2.70.300 NMAC; the ability to operate under these circumstances shall cease if the applicant fails to submit by the deadline specified in writing by the department any additional information identified as being needed to process the application.

B. Revocation or termination of a permit by the department terminates the permittee's right to operate.

C. The submittal of a complete operating permit application shall not protect any source from any applicable requirement, including any requirement that the source have a preconstruction permit under Title I of the federal act or state regulations.

D, Requirement for permit under 20.2.72 NMAC.

(1) Part 70 sources that have an operating permit and do not have a permit issued under 20.2.72 NMAC or 20.2.74 NMAC shall submit a complete application for a permit under 20.2.72 NMAC within 180 days of September 6, 2006. The department shall consider and may grant reasonable requests for extension of this deadline on a case-by-case basis.

(2) Part 70 sources that do not have an operating permit or a permit under 20.2.72 NMAC upon the effective date of this subsection shall submit an application for a permit under 20.2.72 NMAC within 60 days after submittal of an application for an operating permit.

(3) Paragraphs 1 and 2 of this subsection shall not apply to sources that have demonstrated compliance with both the national and state ambient air quality standards through dispersion modeling or other method approved by the department and that have requested incorporation of conditions in their operating permit to ensure compliance with these standards.
[11/30/95; 20.2.70.201 NMAC - Rn, 20 NMAC 2.70.II.201, 06/14/02; A, 9/6/06]

20.2.70.202 SOURCE CATEGORY EXEMPTIONS:

A. The following source categories are exempted from the obligation to obtain an operating permit:

(1) All sources and source categories that would be required to obtain a permit solely because they are subject to 40 CFR Part 60, Subpart AAA – Standards of Performance for New Residential Wood Heaters;

(2) All sources and source categories that would be required to obtain a permit solely because they are subject to 40 CFR Part 61, Subpart M -- National Emission Standard for Hazardous Air Pollutants for Asbestos, section 61.145, Standard for Demolition and Renovation;

(3) Except as required under sections 20.2.70.500 NMAC - 20.2.70.599 NMAC, any source that would be required to obtain a permit solely because of emissions of radionuclides; and

(4) Any source in a source category exempted by the Administrator, by regulation, after notice and comment.

B. Non-major sources, including those subject to sections 111 or 112 of the Federal Act, are exempt from the obligation to obtain a Part 70 (20.2.70 NMAC) permit until such time that the Administrator completes a rulemaking that requires such sources to obtain operating permits.

C. Any source exempted from the requirement to obtain an operating permit may opt to apply for a permit under this Part.

D. No permit for a solid waste incineration unit shall be issued by the Department if a New Mexico state agency is responsible, in whole or in part, for the design and construction or operation of the unit. In such cases, applications shall be made to the Administrator. Department review or approval of solid waste incineration units shall not constitute responsibility for the design, construction, or operation of the unit.
[11/30/95; 20.2.70.202 NMAC - Rn, 20 NMAC 2.70.202 06/14/02]

20.2.70.203 EXISTING MAJOR SOURCES WHICH ARE NOT REQUIRED TO HAVE A PERMIT UNDER 20.2.72 NMAC (CONSTRUCTION PERMITS):

A. The owner or operator of any major source may reverse or avoid designation as a major source under this Part by obtaining a permit under 20.2.72 NMAC (Construction Permits) which includes federally enforceable conditions which restrict the potential to emit of the source to non-major emission rates. Such conditions may include emissions limitations, process restrictions and/or limitations, restrictions on annual hours of operation, or other conditions which reduce the facility's potential to emit.

B. [REPEALED]
[11/30/95; A, 11/19/97; 20.2.70.203 NMAC - Rn, 20 NMAC 2.70.203 06/14/02]

20.2.70.204 BERNALILLO COUNTY:

For the operation of sources within Bernalillo County, the applicant shall make such applications to the Air Pollution Control Division of the Albuquerque Environmental Health Department or its successor agency or authority.
[11/30/95; 20.2.70.204 NMAC – Rn, 20 NMAC 2.70.204 06/14/02]

20.2.70.205 INDIAN TRIBAL JURISDICTION:

The requirements of this Part do not apply to sources within Indian Tribal jurisdiction. For the operation of sources in that jurisdiction, the applicant should make such applications to the Tribal Authority or to the Administrator, as appropriate.
[11/30/95; 20.2.70.205 NMAC - Rn, 20 NMAC 2.70.205 06/14/02]

20.2.70.206 to 20.2.70.299 [RESERVED]

20.2.70.300 PERMIT APPLICATIONS:

A. Duty to apply. For each Part 70 source, the owner or operator shall submit a timely and complete permit application in accordance with this part.

B. Timely application. A timely application for a source applying for a permit under this part is:

(1) for first time applications, one that is submitted within twelve (12) months after the source commences operation as a Part 70 source;

(2) for purposes of permit renewal, one that is submitted at least twelve (12) months prior to the date of permit expiration;

(3) for the acid rain portion of permit applications for initial phase II acid rain sources under Title IV of the federal act, by January 1, 1996 for sulfur dioxide, and by January 1, 1998 for nitrogen oxides;

C. Completeness of application.

(1) To be deemed complete, an application must provide all information required pursuant to Subsection D of 20.2.70.300 NMAC, except that applications for permit modifications need supply such information only if it is related to the proposed change.

(2) If, while processing an application, regardless of whether it has been determined or deemed to be complete, the department determines that additional information is necessary to evaluate or take final action on that application, it may request such information in writing and set a reasonable deadline for a response.

(3) Any applicant who fails to submit any relevant facts or who has submitted incorrect information in a permit application or in a supplemental submittal shall, upon becoming aware of such failure or incorrect submittal, promptly submit such supplementary facts or corrected information. In addition, an applicant shall provide further information as necessary to address any requirements that become applicable to the source after the date it filed a complete application but prior to release of a draft permit.

(4) The applicant's ability to operate without a permit, as set forth in Paragraph (2) of Subsection A of 20.2.70.201 NMAC, shall be in effect from the date a timely application is submitted until the final permit is issued or disapproved, provided that the applicant adequately submits any requested additional information by the deadline specified by the department.

D. Content of application. Any person seeking a permit under this part shall do so by filing a written application with the department. The applicant shall submit three (3) copies of the permit application, or more, as requested by the department. An applicant may not omit information needed to determine the applicability of, or to impose, any applicable requirement, or to evaluate the fee amount required under 20.2.71 NMAC (operating permit emission fees). Fugitive emissions shall be included in the permit application in the same manner as stack emissions, regardless of whether the source category in question is included in the list of sources contained in the definition of major source. All applications shall meet the following requirements.

(1) Be made on forms furnished by the department, which for the acid rain portions of permit applications and compliance plans shall be on nationally-standardized forms to the extent required by regulations promulgated under Title IV of the federal act.

(2) State the company's name and address (and, if different, plant name and address), together with the names and addresses of the owner(s), responsible official and the operator of the source, any subsidiaries or parent companies, the company's state of incorporation or principal registration to do business and corporate or partnership relationship to other permittees subject to this part, and the telephone numbers and names of the owners' agent(s) and the site contact(s) familiar with plant operations.

(3) State the date of the application.

(4) Include a description of the source's processes and products (by standard industrial classification code) including any associated with alternative scenarios identified by the applicant, and a map, such as the 7.5 minute topographic quadrangle map published by the United States geological survey or the most detailed map available showing the exact location of the source. The location shall be identified by latitude and longitude or by UTM coordinates.

(5) For all emissions of all air pollutants for which the source is major and all emissions of regulated air pollutants, provide all emissions information, calculations and computations for the source and for each emissions unit, except for insignificant activities (as defined in 20.2.70.7 NMAC). This shall include:

(a) a process flow sheet of all components of the facility which would be involved in routine operations and emissions;

(b) identification and description of all emissions points in sufficient detail to establish the basis for fees and applicability of requirements of the state and federal acts;

(c) emissions rates in tons per year, pounds per hour and in such terms as are necessary to establish compliance consistent with the applicable standard reference test method;

(d) specific information such as that regarding fuels, fuel use, raw materials, or production rates, to the extent it is needed to determine or regulate emissions;

(e) identification and full description, including all calculations and the basis for all control efficiencies presented, of air pollution control equipment and compliance monitoring devices or activities;

(f) the maximum and standard operating schedules of the source, as well as any work practice standards or limitations on source operation which affect emissions of regulated pollutants;

(g) if requested by the department, an operational plan defining the measures to be taken to mitigate source emissions during startups, shutdowns and emergencies;

(h) other relevant information as the department may reasonably require or which are required by any applicable requirements (including information related to stack height limitations developed pursuant to Section 123 of the federal act); and

(i) for each alternative operating scenario identified by the applicant, all of the information required in Subparagraphs (a) through (h) above, as well as additional information determined to be necessary by the department to define such alternative operating scenarios.

(6) Provide a list of insignificant activities (as defined in 20.2.70.7 NMAC) at the source, their emissions, to the extent required by the department, and any information necessary to determine applicable requirements.

(7) Provide a citation and description of all applicable air pollution control requirements, including:

(a) sufficient information related to the emissions of regulated air pollutants to verify the requirements that are applicable to the source; and

(b) a description of or reference to any applicable test method for determining compliance with each applicable requirement.

(8) Provide an explanation of any proposed exemptions from otherwise applicable requirements.

(9) Provide other specific information that may be necessary to implement and enforce other requirements of the state or federal acts or to determine the applicability of such requirements, including information necessary to collect any permit fees owed under 20.2.71 NMAC (operating permit emission fees).

(10) Provide certification of compliance, including all of the following.

(a) A certification, by a responsible official consistent with Subsection E of 20.2.70.300 NMAC, of the source's compliance status for each applicable requirement. For national ambient air quality standards, certifications shall be based on the following.

(i) For first time applications, this certification shall be based on modeling submitted with the application for a permit under 20.2.72 NMAC.

(ii) For permit renewal applications, this certification shall be based on compliance with the relevant terms and conditions of the current operating permit.

(b) A statement of methods used for determining compliance, including a description of monitoring, recordkeeping, and reporting requirements and test methods.

(c) A statement that the source will continue to be in compliance with applicable requirements for which it is in compliance, and will, in a timely manner or at such schedule expressly required by the applicable requirement, meet additional applicable requirements that become effective during the permit term.

(d) A schedule for submission of compliance certifications during the permit term, to be submitted no less frequently than annually, or more frequently if specified by the underlying applicable requirement or by the department.

(e) A statement indicating the source's compliance status with any enhanced monitoring and compliance certification requirements of the federal act.

(11) For sources that are not in compliance with all applicable requirements at the time of permit application, provide a compliance plan that contains all of the following.

(a) A description of the compliance status of the source with respect to all applicable requirements.

(b) A narrative description of how the source will achieve compliance with such requirements for which it is not in compliance.

(c) A schedule of remedial measures, including an enforceable sequence of actions with milestones, leading to compliance with such applicable requirements. The schedule of compliance shall be at least as stringent as that contained in any consent decree or administrative order to which the source is subject, and the obligations of any consent decree or administrative order shall not be in any way diminished by the schedule of compliance. Any such schedule of compliance shall be supplemental to, and shall not prohibit the department from taking any enforcement action for noncompliance with, the applicable requirements on which it is based.

(d) A schedule for submission of certified progress reports no less frequently than every six (6) months.

(e) For the portion of each acid rain source subject to the acid rain provisions of Title IV of the federal act, the compliance plan content requirements specified in this paragraph, except as specifically superseded by regulations promulgated under Title IV of the federal act with regard to the schedule and method(s) the source will use to achieve compliance with the acid rain emissions limitations.

E. Certification. Any document, including any application form, report, or compliance certification, submitted pursuant to this part shall contain certification by a responsible official of truth, accuracy, and completeness. This certification and any other certification required under this part shall state that, based on information and belief formed after reasonable inquiry, the statements and information in the document are true, accurate, and complete.

[11/30/95; A, 11/14/98; 20.2.70.300 NMAC - Rn, 20 NMAC 2.70.III.300, 06/14/02; A, 9/6/06; A, 01/01/11]

20.2.70.301 CONFIDENTIAL INFORMATION PROTECTION:

A. All confidentiality claims made regarding material submitted to the Department under this Part shall be reviewed under the provisions of the New Mexico Air Quality Control Act section 74-2-11 NMSA 1978 and the New Mexico Inspection of Public Records Act, sections 14-2-1 et seq.

NMSA 1978.

B. In the case where an applicant or permittee has submitted information to the Department under a claim of confidentiality, the Department may also require the applicant or permittee to submit a copy of such information directly to the Administrator.

C. An operating permit is a public record, and not entitled to protection under section 114(c) of the Federal Act.

[11/30/95; 20.2.70.301 NMAC - Rn, 20 NMAC 2.70.301 06/14/02]

20.2.70.302 PERMIT CONTENT:

A. Permit conditions.

(1) The department shall specify conditions upon a permit, including emission limitations and sufficient operational requirements and limitations, to assure compliance with all applicable requirements at the time of permit issuance or as specified in the approved schedule of compliance. The permit shall:

(a) for major sources, include all applicable requirements for all relevant emissions units in the major source;

(b) for any non-major source subject to 20.2.70.200 NMAC - 20.2.70.299 NMAC, include all applicable requirements which apply to emissions units that cause the source to be subject to this part;

(c) specify and reference the origin of and authority for each term or condition, and identify any difference in form as compared to the applicable requirement upon which the term or condition is based;

(d) *include a severability clause to ensure the continued validity of the various permit* requirements in the event of a challenge to any portions of the permit;

(e) include a provision to ensure that the permittee pays fees to the department consistent with the fee schedule in 20.2.71 NMAC (Operating Permit Emission Fees); and

(f) for purposes of the permit shield, identify any requirement specifically identified in the permit application or significant permit modification that the department has determined is not applicable to the source, and state the basis for any such determination.

(2) Each permit issued shall, additionally, include provisions stating the following.

(a) The permittee shall comply with all terms and conditions of the permit. Any permit noncompliance is grounds for enforcement action. In addition, noncompliance with federally enforceable permit conditions constitutes a violation of the federal act.

(b) *It shall not be a defense for a permittee in an enforcement action that it would have* been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

(c) The permit may be modified, reopened and revised, revoked and reissued, or terminated for cause in accordance with 20.2.70.405 NMAC.

(d) The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or of a notification of planned changes or anticipated noncompliance shall not stay any permit condition.

(e) The permit does not convey any property rights of any sort, or any exclusive privilege.

(f) Within the period specified by the department, the permittee shall furnish any *information that the department may request in writing to determine whether cause exists for reopening* and revising, revoking and reissuing, or termination of the permit or to determine compliance with the permit. Upon request, the permittee shall also furnish to the department copies of records required by the permit to be maintained.

(3) The terms and conditions for all alternative operating scenarios identified in the application and approved by the department:

(a) shall require that the permittee maintain a log at the permitted facility which documents, contemporaneously with any change from one operating scenario to another, the scenario under which the facility is operating; and

(b) shall, for each such alternative scenario, meet all applicable requirements and the requirements of this part.

(4) The department may impose conditions regulating emissions during startup and shutdown.

(5) All permit terms and conditions which are required under the federal act or under any of its applicable requirements, including any provisions designed to limit a source's potential to emit, are enforceable by the administrator and citizens under the federal act. The permit shall specifically designate as not being federally enforceable under the federal act any terms or conditions included in the permit that are not required under the federal act or under any of its applicable requirements.

(6) The issuance of a permit, or the filing or approval of a compliance plan, does not relieve any person from civil or criminal liability for failure to comply with the provisions of the Air Quality Control Act, the federal act, federal regulations thereunder, any applicable regulations of the board, and any other applicable law or regulation.

(7) The department may include part or all of the contents of the application as terms and conditions of the permit or permit modification. The department shall not apply permit terms and conditions upon emissions of regulated pollutants for which there are no applicable requirements, unless the source is major for that pollutant.

(8) Fugitive emissions from a source shall be included in the operating permit in the same manner as stack emissions, regardless of whether the source category in question is included in the list of sources contained in the definition of major source.

(9) The acid rain portion of operating permits for acid rain sources shall additionally:

(a) state that, where an applicable requirement of the federal act is more stringent than an applicable requirement of regulations promulgated under Title IV of the federal act, both provisions shall be incorporated into the permit and shall be enforceable by the administrator; and

(b) contain a permit condition prohibiting emissions exceeding any allowances that the acid rain source lawfully holds under Title IV of the federal act or the regulations promulgated thereunder; no permit modification under this part shall be required for increases in emissions that are authorized by allowances acquired pursuant to the acid rain program, provided that such increases do not require a permit modification under any other applicable requirement; no limit shall be placed on the number of allowances held by the acid rain source; the permittee may not use allowances as a defense to noncompliance with any other applicable requirement; any such allowance shall be accounted for according to the procedures established in regulations promulgated under Title IV of the federal act.

B. Permit duration. The department shall issue operating permits for a fixed term of five (5) years.

C. Monitoring.

(1) Each permit shall contain all emissions monitoring requirements, and analysis procedures or test methods, required to assure and verify compliance with the terms and conditions of the permit and applicable requirements, including any procedures and methods promulgated by the administrator.

(2) Where the applicable requirement does not require periodic testing or instrumental or noninstrumental monitoring (which may consist of recordkeeping designed to serve as monitoring), the permit shall require periodic monitoring sufficient to yield reliable data from the relevant time period that are representative of the source's compliance with the permit, as reported pursuant to Subsection E of 20.2.70.302 NMAC. Such monitoring requirements shall assure use of terms, test methods, units, averaging periods, and other statistical conventions consistent with the applicable requirement.

(3) The permit shall also contain specific requirements concerning the use, maintenance, and, when appropriate, installation of monitoring equipment or methods.

D. Recordkeeping.

(1) The permit shall require recordkeeping sufficient to assure and verify compliance with the terms and conditions of the permit, including recordkeeping of:

(a) the date, place as defined in the permit, and time of sampling or measurements;

(b) the date(s) analyses were performed;

(c) the company or entity that performed the analyses;

(d) the analytical techniques or methods used;

(e) the results of such analyses; and

(f) the operating conditions existing at the time of sampling or measurement.

(2) Records of all monitoring data and support information shall be retained for a period of at least five (5) years from the date of the monitoring sample, measurement, report, or application. Supporting information includes all calibration and maintenance records and all original strip-chart recordings for continuous monitoring instrumentation, and copies of all reports required by the permit.

E. Reporting. The permit shall require reporting sufficient to assure and verify compliance with the terms and conditions of the permit and all applicable requirements, including all of the following.

(1) Submittal of reports of any required monitoring at least every six (6) months. The reports shall be due to the department within forty-five (45) days of the end of the permittee's reporting period. All instances of deviations from permit requirements, including emergencies, must be clearly identified in such reports. All required reports must be certified by a responsible official consistent with Subsection E of 20.2.70.300 NMAC.

(2) Prompt reporting of all deviations from permit requirements, including those attributable to upset conditions as defined in the permit, the probable cause of such deviations, and any corrective actions or preventive measures taken. The report shall be contained in the report submitted in accordance with the timeframe given in Paragraph (1) of this section.

(3) Submittal of compliance certification reports at least every twelve (12) months (or more frequently if so specified by an applicable requirement) certifying the source's compliance status with terms and conditions contained in the permit, including emission limitations, standards, or work practices. The reports shall be due to the department within thirty (30) days of the end of the permittee's reporting period. Such compliance certifications shall be submitted to the administrator as well as to the department and shall include:

(a) the identification of each term or condition of the permit that is the basis of the certification;

(b) the compliance status of the source;

(c) whether compliance was continuous or intermittent;

(d) the method(s) used for determining the compliance status of the source, currently and during the reporting period identified in the permit; and

(e) such other facts as the department may require to determine the compliance status of the source.

(4) Such additional provisions as may be specified by the administrator to determine the compliance status of the source.

F. Portable and temporary sources. The department may issue permits for portable and temporary sources which allow such sources to relocate without undergoing a permit modification. Such permits shall not apply to acid rain sources and shall include conditions to assure that:

(1) the source is installed at all locations in a manner conforming with the permit;

(2) the source shall comply with all applicable requirements and all other provisions of this part at all authorized locations;

(3) the owner or operator shall notify the department in writing at least fifteen (15) calendar days in advance of each change in location;

(4) notification shall include a legal description of where the source is to be relocated and how long it will be located there; and

(5) emissions from the source shall not, at any location, result in or contribute to an exceedance of a national ambient air quality standard or increment or visibility requirement under Part C of Title I of the federal act; the department may require dispersion modeling to assure compliance at any location.

G. Compliance. To assure and verify compliance with the terms and conditions of the permit and with this part, permits shall also include all the following.

(1) Require that, upon presentation of credentials and other documents as may be required by law, the permittee shall allow authorized representatives of the department to perform the following:

(a) enter upon the permittee's premises where a source is located or emission related activity is conducted, or where records must be kept under the conditions of the permit;

(b) have access to and copy any records that must be kept under the conditions of the permit;

(c) inspect any facilities, equipment (including monitoring and air pollution control equipment), practices, or operations regulated or required under the permit; and

(d) sample or monitor any substances or parameters for the purpose of assuring compliance with the permit or applicable requirements or as otherwise authorized by the federal act.

(2) Require that sources required under Paragraph (11) of Subsection D of 20.2.70.300 NMAC to have a schedule of compliance submit progress reports to the department at least semiannually, or more frequently if specified in the applicable requirement or by the department. Such progress reports shall be consistent with the schedule of compliance and requirements of Paragraph (11) of Subsection D of 20.2.70.300 NMAC and shall contain:

(a) dates for achieving the activities, milestones, or compliance required in the schedule of compliance, and dates when such activities, milestones or compliance were achieved; and

(b) an explanation of why any dates in the schedule of compliance were not or will not be met, and any preventive or corrective measures adopted.

(3) Include such other provisions as the department may require.

H. Operational flexibility.

(1) Section 502(b)(10) changes.

(a) The permittee may make Section 502(b)(10) changes, as defined in 20.2.70.7 NMAC, without applying for a permit modification, if those changes are not title I modifications and the changes do not cause the facility to exceed the emissions allowable under the permit (whether expressed as a rate of emissions or in terms of total emissions).

(b) For each such change, the permittee shall provide written notification to the department and the administrator at least seven (7) days in advance of the proposed changes. Such notification shall include a brief description of the change within the permitted facility, the date on which the change will occur, any change in emissions, and any permit term or condition that is no longer applicable as a result of the change.

(c) The permittee and department shall attach each such notice to their copy of the relevant permit.

(d) If the written notification and the change qualify under this provision, the permittee is not required to comply with the permit terms and conditions it has identified that restrict the change. If the change does not qualify under this provision, the original terms of the permit remain fully enforceable.

(2) Emissions trading within a facility.

(a) The department shall, if an applicant requests it, issue permits that contain terms and conditions allowing for the trading of emissions increases and decreases in the permitted facility solely for the purpose of complying with a federally enforceable emissions cap that is established in the permit in addition to any applicable requirements. Such terms and conditions shall include all terms and conditions required under 20.2.70.302 NMAC to determine compliance. If applicable requirements apply to the requested emissions trading, permit conditions shall be issued only to the extent that the applicable requirements provide for trading such increases and decreases without a case-by-case approval.

(b) The applicant shall include in the application proposed replicable procedures and permit terms that ensure the emissions trades are quantifiable and enforceable. The department shall not include in the emissions trading provisions any emissions units for which emissions are not quantifiable or for which there are no replicable procedures to enforce the emissions trades. The permit shall require compliance with all applicable requirements.

(c) For each such change, the permittee shall provide written notification to the department and the administrator at least seven (7) days in advance of the proposed changes. Such notification shall state when the change will occur and shall describe the changes in emissions that will result and how these increases and decreases in emissions will comply with the terms and conditions of the permit.

(d) The permittee and department shall attach each such notice to their copy of the relevant permit.

I. Off-permit changes.

(1) Permittees are allowed to make, without a permit modification, changes that are not addressed or prohibited by the operating permit, if:

(a) each such change meets all applicable requirements and shall not violate any existing permit term or condition;

(b) such changes are not subject to any requirements under Title IV of the federal act and are not Title I modifications;

(c) such changes are not subject to permit modification procedures under 20.2.70.404 NMAC; and

(d) the permittee provides contemporaneous written notice to the department and US EPA of each such change, except for changes that qualify as insignificant activities. Such written notice shall describe each such change, including the date, any change in emissions, pollutants emitted and any applicable requirement that would apply as a result of the change.

(2) The permittee shall keep a record describing changes made at the source that result in emissions of a regulated air pollutant subject to an applicable requirement, but not otherwise regulated under the permit, and the emissions resulting from those changes.

J. Permit shield.

(1) Except as provided in this part, the department shall expressly include in a Part 70 (20.2.70 NMAC) permit a provision stating that compliance with the conditions of the permit shall be deemed compliance with any applicable requirements as of the date of permit issuance, provided that:

(a) such applicable requirements are included and are specifically identified in the permit; or

(b) the department, in acting on the permit application or significant permit modification, determines in writing that other requirements specifically identified are not applicable to the source, and the permit includes the determination or a concise summary thereof.

(2) A Part 70 (20.2.70 NMAC) permit that does not expressly state that a permit shield exists for a specific provision shall be presumed not to provide such a shield for that provision.

(3) Nothing in this section or in any Part 70 (20.2.70 NMAC) permit shall alter or affect the following:

(a) the provisions of Section 303 of the federal act -- Emergency Powers, including the authority of the administrator under that section, or the provisions of the New Mexico Air Quality Control Act, Section 74-2-10 NMSA 1978;

(b) the liability of an owner or operator of a source for any violation of applicable requirements prior to or at the time of permit issuance;

(c) the applicable requirements of the acid rain program, consistent with Section 408(a) of the federal act; or

(d) the ability of US EPA to obtain information from a source pursuant to Section 114 of the federal act, or the department to obtain information subject to the New Mexico Air Quality Control Act, Section 74-2-13 NMSA 1978.

(4) The permit shield shall remain in effect if the permit terms and conditions are extended past the expiration date of the permit pursuant to Subsection D of 20.2.70.400 NMAC.

(5) The permit shield shall extend to terms and conditions that allow emission increases and decreases as part of emissions trading within a facility pursuant to Paragraph (2) of Subsection H of 20.2.70.302 NMAC, and to all terms and conditions under each operating scenario included pursuant to Paragraph (3) of Subsection A of 20.2.70.302 NMAC.

(6) The permit shield shall not extend to administrative amendments under Subsection A of 20.2.70.404 NMAC, to minor permit modifications under Subsection B of 20.2.70.404 NMAC, to Section 502(b)(10) changes under Paragraph (1) of Subsection H of 20.2.70.302 NMAC, or to permit terms or conditions for which notice has been given to reopen or revoke all or part under 20.2.70.405 NMAC.

[11/30/95; A, 11/14/98; 20.2.70.302 NMAC - Rn, 20 NMAC 2.70.III.302, 06/14/02; A, 9/6/06; A, 08/01/08]

20.2.70.303 GENERAL PERMITS:

A. Issuance of General Permits:

(1) The Department may, after notice and opportunity for public participation and US EPA and affected program review, issue a general permit covering numerous similar sources. Such sources shall be generally homogenous in terms of operations, processes and emissions, subject to the same or substantially similar requirements, and not subject to case-by-case standards or requirements.

(2) Any general permit shall comply with all requirements applicable to other operating permits and shall identify criteria by which sources may qualify for the general permit.

B. Authorization to Operate under a General Permit:

(1) The owner or operator of a Part 70 source which qualifies for a general permit must:

(a) Apply to the Department for coverage under the terms of the general permit; or

(b) Apply for an operating permit consistent with 20.2.70.300 NMAC.

(2) The Department may, in the general permit, provide for applications which deviate from the requirements of subsection D of 20.2.70.300 NMAC, provided that such applications meet the requirements of the Federal Act and include all information necessary to determine qualification for, and to assure compliance with, the general permit. The Department shall review the application for authorization to operate under a general permit for completeness within thirty (30) days after its receipt of the application.

(3) The Department shall authorize qualifying sources which apply for coverage under the general permit to operate under the terms and conditions of the general permit. The Department shall take final action on a general permit authorization request within ninety (90) days of deeming the application complete.

(4) The Department may grant a request for authorization to operate under a general permit without repeating the public participation procedures required under 20.2.70.401 NMAC. Such an authorization shall not be a permitting action for purposes of administrative review under New Mexico Air Quality Control Act section 74-2-7.H NMSA 1978. Permitting action for the purposes of section 74-2-7 NMSA 1978 shall be the issuance of the general permit.

(5) Authorization to operate under a general permit shall not be granted for acid rain sources unless otherwise provided in regulations promulgated under title IV of the Federal Act.

(6) The permittee shall be subject to enforcement action for operation without an operating permit if the source is later determined not to qualify for the conditions and terms of the general permit.
[11/30/95; 20.2.70.303 NMAC - Rn, 20 NMAC 2.70.303 06/14/02]

20.2.70.304 EMERGENCY PROVISION:

A. An "emergency" means any situation arising from sudden and reasonably unforeseeable events beyond the control of the permittee, including acts of God, which situation requires immediate corrective action to restore normal operation, and that causes the source to exceed a technology-based emission limitation under the permit due to unavoidable increases in emissions attributable to the emergency. An emergency shall not include noncompliance to the extent caused by improperly designed equipment, lack of preventive maintenance, or careless or improper operation.

B. An emergency constitutes an affirmative defense to an action brought for noncompliance with such technology-based emission limitations if the permittee has demonstrated through properly signed, contemporaneous operating logs, or other relevant evidence that:

(1) an emergency occurred and that the permittee can identify the cause(s) of the emergency;

(2) the permitted facility was at the time being properly operated;

(3) during the period of the emergency the permittee took all reasonable steps to minimize levels of emissions that exceeded the emission standards or other requirements in the permit; and

(4) the permittee submitted notice of the emergency to the department within 2 working *days of the time when emission limitations were exceeded due to the emergency; this notice fulfills the* requirement of Paragraph (2) of Subsection E of 20.2.70.302 NMAC; this notice must contain a description of the emergency, any steps taken to mitigate emissions, and corrective actions taken.

C. In any enforcement proceeding, the permittee seeking to establish the occurrence of an emergency has the burden of proof.

D. This provision is in addition to any emergency or upset provision contained in any applicable requirement.

[11/30/95; 20.2.70.304 NMAC - Rn, 20 NMAC 2.70.III.304, 06/14/02; A, 9/6/06; A, 08/01/08]

20.2.70.305 to 20.2.70.399 [RESERVED]

20.2.70.400 ACTION ON PERMIT APPLICATIONS:

A. A permit (including permit renewal) or permit modification shall only be issued if all of the following conditions have been met:

(1) The Department has received a complete application for a permit, permit modification, or permit renewal, except that a complete application need not be received before issuance of a general permit under 20.2.70.303 NMAC;

(2) Except for administrative and minor permit modifications, the Department has complied with the requirements for public participation procedures under 20.2.70.401 NMAC;

(3). Except for administrative amendments, the Department has complied with the requirements for notifying and responding to affected programs under 20.2.70.402 NMAC;

(4) The conditions of the permit provide for compliance with all applicable requirements and the requirements of this Part; and

(5) The Administrator has received a copy of the proposed permit and any notices required under 20.2.70.402 NMAC, and has not objected to issuance of the permit within the time period specified within that section.

B. The Department shall, within sixty (60) days after its receipt of an application for a permit or significant permit modification, review such application for completeness. Unless the Department determines that an application is not complete, requests additional information or otherwise notifies the applicant of incompleteness within sixty (60) days of receipt of an application, the application shall be deemed complete. When additional information is requested by the Department prior to ruling an application complete, receipt of such information shall be processed as a new application for purposes of this section. If the application is judged complete, a certified letter to that effect shall be sent to the applicant. If the application is judged incomplete a certified letter shall be sent to the applicant stating what additional information or points of clarification are necessary to judge the application complete.

C. The Department shall take final action on each permit application (including a request for permit renewal) within eighteen (18) months after an application is ruled complete by the Department, except that:

(1) For sources in operation on or before December 19, 1994 and which submit to the Department timely and complete applications in accordance with 20.2.70.300 NMAC, the Department shall take final action on one third of such applications annually over a period not to exceed three (3) years after such effective date;

(2) Any complete permit application containing an early reduction demonstration under section 112(i)(5) of the Federal Act shall be acted on within nine (9) months of deeming the application complete; and

(3) The acid rain portion of permits for acid rain sources shall be acted upon in accordance with the deadlines in title IV of the Federal Act and the regulations promulgated thereunder.

D. If a timely and complete application for a permit renewal is submitted, consistent with 20.2.70.300 NMAC, but the Department has failed to issue or disapprove the renewal permit before the end of the term of the previous permit, then the permit shall not expire and all the terms and conditions of the permit shall remain in effect until the renewal permit has been issued or disapproved.

E. Permits being renewed are subject to the same procedural requirements, including those for public participation, affected program and US EPA review, that apply to initial permit issuance.

F. The Department shall state within the draft permit the legal and factual basis for the draft permit conditions (including references to the applicable statutory or regulatory provisions).

G. The Department shall grant or disapprove the permit based on information contained in the Department's administrative record. The administrative record shall consist of the application, any additional information submitted by the applicant, any evidence or written comments submitted by interested persons, any other evidence considered by the Department, and, if a public hearing is held, the evidence submitted at the hearing.

H. If the Department grants or disapproves a permit or permit modification, the Department shall notify the applicant by certified mail of the action taken and the reasons therefor. If the Department grants a permit or modification, the Department shall mail the permit or modification, including all terms and conditions, to the applicant by certified mail.

I. Voluntary Discontinuation. Upon request by the permittee, the Department shall permanently discontinue a Part 70 (20.2.70 NMAC) permit. Permit discontinuance terminates the permittee's right to operate the source under the permit. The Department shall confirm the permit discontinuance by certified letter to the permittee.

J. No permit shall be issued by failure of the Department to act on an application or renewal.

[11/30/95; 20.2.70.400 NMAC - Rn, 20 NMAC 2.70.400 06/14/02]

20.2.70.401 PUBLIC PARTICIPATION:

A. Proceedings for all permit issuances (including renewals), significant permit modifications, reopenings, revocations and terminations, and all modifications to the Department's list of insignificant activities, shall include public notice and provide an opportunity for public comment. The Department shall provide thirty (30) days for public and affected program comment. The Department may hold a public hearing on the draft permit, a proposal to suspend, reopen, revoke or terminate a permit, or for any reason it deems appropriate, and shall hold such a hearing in the event of significant public interest. The Department shall give notice of any public hearing at least thirty (30) days in advance of the hearing.

B. Public notice and notice of public hearing shall be given by publication in a newspaper of general circulation in the area where the source is located or in a state publication designed to give general public notice, to persons on a mailing list developed by the Department, including those who request in writing to be on the list, and by other means if necessary to assure adequate notice to the affected public.

C. The public notice shall identify:

(1) The affected facility;
(2) The names and addresses of the applicant or permittee and its owners;
(3) The name and address of the Department;
(4) The activity or activities involved in the permit action;

(5) The emissions change(s) involved in any permit modification;

(6) The name, address and telephone number of a person from whom interested persons may obtain additional information, including copies of the permit draft, the application, and relevant supporting materials;

(7) A brief description of the comment procedures required by the Department; and

(8) As appropriate, a statement of procedures to request a hearing, or the time and place of any scheduled hearing.

D. Notice of public hearing shall identify:

(1) The affected facility;

(2) The names and addresses of the applicant or permittee and its owners;

(3) The name and address of the Department;

(4) The activity or activities involved in the permit action;

(5) The name, address and telephone number of a person from whom interested persons may obtain additional information;

(6) A brief description of hearing procedures; and

(7) The time and place of the scheduled hearing.

E. Public hearings shall be held in the geographic area likely to be impacted by the source. The time, date, and place of the hearing shall be determined by the Department. The Department shall appoint a hearing officer. A transcript of the hearing shall be made at the request of either the Department or the applicant and at the expense of the person requesting the transcript. At the hearing, all interested persons shall be given a reasonable chance to submit data, views or arguments orally or in writing and to examine witnesses testifying at the hearing.

F. The Department shall keep a record of the commenters and also of the issues raised during the public participation process so that the Administrator may fulfill his or her obligation under section 505(b)(2) of the Federal Act to determine whether a citizen petition may be granted. Such records shall be available to the public upon request.

G. The Department shall provide such notice and opportunity for participation by affected programs as is provided for by 20.2.70.402 NMAC.

[11/30/95; 20.2.70.401 NMAC - Rn, 20 NMAC 2.70.401 06/14/02]

20.2.70.402 REVIEW BY THE ADMINISTRATOR AND AFFECTED PROGRAMS:

A. Notification: The Department shall not issue an operating permit (including permit renewal or reissuance), minor permit modification or significant permit modification, until affected programs and the Administrator have had an opportunity to review the proposed permit as required under this section. Permits for source categories waived by the Administrator from this requirement and any permit terms or conditions which are not required under the Federal Act or under any of its requirements are not subject to Administrator review or approval.

(1) Within five (5) days of notification by the Department that the application has been determined complete, the applicant shall provide a copy of the complete permit application (including the compliance plan and all additional materials submitted to the Department) directly to the Administrator. The permit or permit modification shall not be issued without certification to the Department of such notification. The Department shall provide to the Administrator a copy of each draft permit, each proposed permit, each final operating permit, and any other relevant information requested by the Administrator.

(2) The Department shall provide notice of each draft permit to any affected program on or

before the time that the Department provides this notice to the public under 20.2.70.401 NMAC, except to the extent that minor permit modification procedures require the timing of the notice to be different.

(3) The Department shall keep for five (5) years such records and submit to the Administrator such information as the Administrator may reasonably require to ascertain whether the state program complies with the requirements of the Federal Act or related applicable requirements.

B. Responses to Objections:

(1) No permit for which an application must be transmitted to the Administrator under this Part shall be issued by the Department if the Administrator, after determining that issuance of the proposed permit would not be in compliance with applicable requirements, objects to such issuance in writing within forty-five (45) days of receipt of the proposed permit and all necessary supporting information.

(2) If the Administrator does not object in writing under paragraph (1) of subsection B of 20.2.70.402 NMAC, any person may, within sixty (60) days after the expiration of the Administrator's 45-day review period, petition the Administrator to make such objection. Any such petition shall be based only on objections to the permit that were raised with reasonable specificity during the public comment period provided for in 20.2.70.401 NMAC, unless the petitioner demonstrates that it was impracticable to raise such objections within such period, or unless the grounds for such objection arose after such period. If the Administrator objects to the permit as a result of a petition filed under this paragraph, the Department shall not issue the permit until the Administrator's objection has been resolved, except that a petition for review does not stay the effectiveness of a permit or its requirements if the permit was issued after the end of the 45-day review period and prior to the Administrator's objection.

(3) The Department, as part of the submittal of the proposed permit to the Administrator (or as soon as possible after the submittal for minor permit modification procedures allowed under subsection B of 20.2.70.404 NMAC), shall notify the Administrator and any affected program in writing of any refusal by the Department to accept all recommendations for the proposed permit that the affected program submitted during the public or affected program review period. The notice shall include the Department's reasons for not accepting any such recommendation. The Department is not required to accept recommendations that are not based on federally enforceable applicable requirements.

[11/30/95; 20.2.70.402 NMAC – Rn, 20 NMAC 2.70.402 06/14/02]

20.2.70.403 PETITIONS FOR REVIEW OF FINAL ACTION:

A. Hearing before the board:

(1) Any person who participated in a permitting action before the department and who is adversely affected by such permitting action may file a petition for hearing before the board. For the purposes of this section, permitting action shall include the failure of the department to take final action on an application for a permit (including renewal) or permit modification within the time specified in this part.

(2) The petition shall be made in writing to the board within thirty (30) days from the date notice is given of the department's action and shall specify the portions of the permitting action to which the petitioner objects, certify that a copy of the petition has been mailed or hand-delivered as required by this paragraph, and attach a copy of the permitting action for which review is sought. Unless a timely request for hearing is made, the decision of the department shall be final. The petition shall be copied simultaneously to the department upon receipt of the appeal notice. If the petitioner is not the applicant or permittee, the petitioner shall mail or hand-deliver a copy of the petition to the applicant or permittee.

The department shall certify the administrative record to the board.

(3) If a timely request for hearing is made, the board shall hold a hearing within sixty (60) days of receipt of the petition in accordance with New Mexico Air Quality Control Act section 74-2-7 NMSA 1978.

B. Judicial review:

(1) Any person who is adversely affected by an administrative action taken by the board pursuant to subsection A of 20.2.70.403 NMAC may appeal to the Court of Appeals in accordance with New Mexico Air Quality Control Act section 74-2-9 NMSA 1978. Petitions for judicial review must be filed no later than thirty (30) days after the administrative action.

(2) The judicial review provided for by 20.2.70.403 NMAC shall be the exclusive means for obtaining judicial review of the terms and conditions of the permit.

[11/30/95; 20.2.70.403 NMAC Rn, 20 NMAC 2.70.403 06/14/02; A, 08/01/08]

20.2.70.404 PERMIT MODIFICATIONS:

A. Administrative Permit Amendments:

(1) An administrative permit amendment is one that:

(a) Corrects typographical errors;

(b) Provides for a minor administrative change at the source, such as a change in the address or phone number of any person identified in the permit;

(c) Incorporates a change in the permit solely involving the retiring of an emissions unit;

(d) Requires more frequent monitoring or reporting by the permittee; or

(e) Any other type of change which has been determined by the Department and the Administrator to be similar to those in this paragraph.

(2) Changes in ownership or operational control of a source may be made as administrative amendments provided that:

(a) A written agreement, containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittee, has been submitted to the Department, and either the Department has determined that no other change in the permit is necessary, or changes deemed necessary by the Department have been made;

(b) The new owners have submitted the application information required in paragraph (2) of subsection D of 20.2.70.300 NMAC;

(c) No grounds exist for permit termination, as set out in subparagraphs (b) and (c) of paragraph (3) of subsection A of 20.2.70.405 NMAC; and

(d) The permittee has published a public notice of the change in ownership of the source in a newspaper of general circulation in the area where the source is located.

(3) The Department may incorporate administrative permit amendments without providing notice to the public or affected programs, provided that it designates any such permit modifications as administrative permit amendments and submits a copy of the revised permit to the Administrator.

(4) The Department shall take no more than sixty (60) days from receipt of a request for an administrative permit amendment to take final action on such request. The permittee may implement the changes outlined in subparagraphs (a) through (d) of paragraph (1) of subsection A of 20.2.70.404 NMAC immediately upon submittal of the request for the administrative amendment. The permittee may implement the changes outlined in subparagraph (e) of paragraph (1) of subsection A of 20.2.70.404 NMAC or paragraph (2) of subsection A of 20.2.70.404 NMAC upon approval of the administrative amendment by the Department.

B. Minor Permit Modifications:

(1) Minor permit modification procedures may be used only for those permit modifications that:

(a) Do not violate any applicable requirement;

(b) Do not involve relaxation of existing monitoring, reporting, or recordkeeping requirements in the permit;

(c) Do not require or change a case-by-case determination of an emission limitation or other standard, or a source-specific determination for temporary sources of ambient impacts, or a visibility or increment analysis;

(d) Do not seek to establish or change a permit term or condition for which there is no corresponding underlying applicable requirement and that the permittee has assumed to avoid an applicable requirement to which the source would otherwise be subject. Such terms and conditions include any federally enforceable emissions cap assumed to avoid classification as a title I modification and any alternative emissions limit approved pursuant to regulations promulgated under section 112(i)(5) of the Federal Act;

(e) Are not title I modifications; and

(f) Are not required by the Department to be processed as a significant modification pursuant to subsection C of 20.2.70.404 NMAC.

(2) A permittee shall not submit multiple minor permit modification applications that may conceal a larger modification that would not be eligible for minor permit modification procedures. The Department may, at its discretion, require that multiple related minor permit modification applications be submitted as a significant permit modification.

(3) An application requesting the use of minor permit modification procedures shall meet the requirements of subsections C and D of 20.2.70.300 NMAC and shall include:

(a) A description of the change, the emissions resulting from the change, and any new applicable requirements that will apply if the change occurs;

(b) The applicant's suggested draft permit;

(c) Certification by a responsible official, consistent with subsection E of 20.2.70.300 NMAC, that the proposed modification meets the criteria for use of minor permit modification procedures and a request that such procedures be used; and

(d) If the requested permit modification would affect existing compliance plans or schedules, related progress reports, or certification of compliance requirements, an outline of such effects.

(4) The Department shall, within thirty (30) days after its receipt of an application for a minor permit modification, review such application for completeness. Unless the Department determines that an application is not complete, requests additional information or otherwise notifies the applicant of incompleteness within thirty (30) days of receipt of an application, the application shall be deemed complete. If the application is judged complete, a certified letter to that effect shall be sent to the applicant. If the application is judged incomplete a certified letter shall be sent to the applicant stating what additional information or points of clarification are necessary to judge the application complete.

(5) Within five (5) working days of notification by the Department that the minor permit modification application has been determined complete, the applicant shall meet its obligation under subsection A of 20.2.70.402 NMAC to notify the Administrator of the requested permit modification. The Department promptly shall send any notice required under paragraph (2) of subsection A of 20.2.70.402 NMAC and subsection B of 20.2.70.402 NMAC to the Administrator and affected programs.

(6) The permittee may make the change proposed in its minor permit modification application immediately after such application is deemed complete. After the permittee makes the change allowed by the preceding sentence, and until the Department takes any of the actions specified in paragraph (7) of subsection B of 20.2.70.404 NMAC below, the permittee must comply with both the applicable requirements governing the change and the proposed permit terms and conditions. During this time period, the permittee need not comply with the existing permit terms and conditions it seeks to modify. If the permittee fails to comply with its proposed permit terms and conditions during this time period, the existing permit terms and conditions it seeks to modify may be enforced against it.

(7) The Department may not issue a final minor permit modification until after the Administrator's 45-day review period of the proposed permit modification or until US EPA has notified the Department that the Administrator will not object to issuance of the permit modification, although the Department may approve the permit modification prior to that time. Within ninety (90) days of ruling the application complete under minor permit modification procedures or within fifteen (15) days after the end of the Administrator's 45-day review period, whichever is later, the Department shall:

(a) Issue the permit modification as it was proposed;

(b) Disapprove the permit modification application;

(c) Determine that the requested modification does not meet the minor permit modification criteria and should be reviewed under the significant modification procedures; or

(d) Revise the draft permit modification and transmit to the Administrator the new proposed permit modification as required by subsection A of 20.2.70.402 NMAC.

C. Significant Permit Modifications:

(1) A significant permit modification is:

(a) Any revision to an operating permit that does not meet the criteria under the provisions for administrative permit amendments under subsection A of 20.2.70.404 NMAC or for minor permit modifications under subsection B of 20.2.70.404 NMAC above;

(b) Any modification that would result in any relaxation in existing monitoring, reporting or recordkeeping permit terms or conditions;

(c) Any modification for which action on the application would, in the judgment of the Department, require decisions to be made on significant or complex issues; and

(d) Changes in ownership which do not meet the criteria of paragraph (2) of subsection A of 20.2.70.404 NMAC.

(2) For significant modifications which are not required to undergo preconstruction permit review and approval, changes to the source which qualify as significant permit modifications shall not be made until the Department has issued the operating permit modification.

(3) For significant modifications which have undergone preconstruction permit review and approval, the permittee shall:

(a) Before commencing operation, notify the Department in writing of any applicable requirements and operating permit terms and conditions contravened by the modification, emissions units affected by the change, and allowable emissions increases resulting from the modification; and

(b) Within twelve (12) months after commencing operation, file a complete operating permit modification application.

(4) Where an existing operating permit would specifically prohibit such change, the permittee must obtain an operating permit modification before commencing operation or implementing the change.

(5) Significant permit modifications shall meet all requirements of this Part for permit issuance, including those for applications, public participation, review by affected programs and review by the Administrator.

(6) The Department shall complete review on the majority of significant permit modification applications within nine (9) months after the Department rules the applications complete.

D. Modifications to Acid Rain Sources: Administrative permit amendments and permit modifications for purposes of the acid rain portion of the permit shall be governed by regulations promulgated by the Administrator under title IV of the Federal Act.

[11/30/95; 20.2.70.404 NMAC - Rn, 20 NMAC 2.70.404 06/14/02]

20.2.70.405 PERMIT REOPENING, REVOCATION OR TERMINATION:

A. Action by the Department:

(1) Each permit shall include provisions specifying the conditions under which the permit will be reopened prior to the expiration of the permit. A permit shall be reopened and revised for any of the following, and may be revoked and reissued for subparagraphs (c) or (d) of the following:

(a) Additional applicable requirements under the Federal Act become applicable to a major source with a remaining permit term of three (3) or more years. Such a reopening shall be completed not later than eighteen (18) months after promulgation of the applicable requirement. No such reopening is required if the effective date of the requirement is later than the date on which the permit is due to expire, unless the original permit or any of its terms or conditions have been extended past the expiration date of the permit pursuant to subsection D of 20.2.70.400 NMAC;

(b) Additional requirements (including excess emissions requirements) become applicable to a source under the acid rain program promulgated under title IV of the Federal Act. Upon approval by the Administrator, excess emissions offset plans shall be deemed to be incorporated into the permit;

(c) The Department or the Administrator determines that the permit contains a material mistake or that inaccurate statements were made in establishing the terms or conditions of the permit; or

(d) The Department or the Administrator determines that the permit must be revised or revoked and reissued to assure compliance with the applicable requirements.

(2) Proceedings to reopen and revise, or revoke and reissue, a permit shall affect only those parts of the permit for which cause to reopen or revoke exists. Units for which permit conditions have been revoked shall not be operated until permit reissuance. Reopenings shall be made as expeditiously as practicable.

(3) A permit, or an authorization to operate under a general permit, may be terminated when:

(a) The permittee fails to meet the requirements of an approved compliance plan;

(b) The permittee has been in significant or repetitious non-compliance with the operating permit terms or conditions;

(c) The applicant or permittee has exhibited a history of willful disregard for environmental laws of any state or Tribal authority, or of the United States;

(d) The applicant or permittee has knowingly misrepresented a material fact in any application, record, report, plan, or other document filed or required to be maintained under the permit;

(e) The permittee falsifies, tampers with or renders inaccurate any monitoring device or method required to be maintained under the permit;

(f) The permittee fails to pay fees required under the fee schedule in 20.2.71 NMAC (Operating Permit Emission Fees); or

(g) The Administrator has found that cause exists to terminate the permit.

(4) The Department shall, by certified mail, provide a notice of intent to the permittee at least thirty (30) days in advance of the date on which a permit is to be reopened or revoked, or terminated, except that the Department may provide a shorter time period in the case of an emergency. The notice shall state that the permittee may, within 30 (thirty) days of receipt, submit comments or request a hearing on the proposed permit action.

B. Action by the Administrator: Within ninety (90) days, or longer if the Administrator extends this period, after receipt of written notification that the Administrator has found that cause exists to terminate, modify or revoke and reissue a permit, the Department shall forward to the Administrator a proposed determination of termination, modification, or revocation and reissuance, as appropriate. Within ninety (90) days from receipt of an Administrator objection to a proposed determination, the Department shall address and act upon the Administrator's objection.

C. Compliance Orders: Notwithstanding any action which may be taken by the Department or the Administrator under subsections A and B of 20.2.70.405 NMAC, a compliance order issued pursuant to New Mexico Air Quality Control Act section 74-2-12 NMSA 1978 may include a suspension or revocation of any permit or portion thereof.
[11/30/95; 20.2.70.405 NMAC - Rn, 20 NMAC 2.70.405 06/14/02]

20.2.70.406 CITIZEN SUITS:
Pursuant to section 304 of the Federal Act, 42 USC 7604, any person may commence certain civil actions under the Federal Act.
[11/30/95; 20.2.70.406 NMAC - Rn, 20 NMAC 2.70.406 06/14/02]

20.2.70.407 VARIANCES:
Pursuant to New Mexico Air Quality Control Act section 74-2-8 NMSA 1978, applicants and permittees may seek a variance from the non-federally enforceable provisions of this Part.
[11/30/95; 20.2.70.407 NMAC - Rn, 20 NMAC 2.70.407 06/14/02]

20.2.70.408 ENFORCEMENT:
Notwithstanding any other provision in the New Mexico State Implementation Plan approved by the Administrator, any credible evidence may be used for the purpose of establishing whether a person has violated or is in violation of the terms or conditions of a permit issued pursuant to this Part.

A. Information from the use of the following methods is presumptively credible evidence of whether a violation has occurred at the source:

(1) A monitoring or information gathering method approved for the source pursuant to this Part and incorporated in an operating permit; or

(2) Compliance methods specified in the New Mexico State Implementation Plan.

B. The following testing, monitoring or information gathering methods are presumptively credible testing, monitoring or information gathering methods:

(1) Any federally enforceable monitoring or testing methods, including those in 40 CFR parts 51, 60, 61 and 75; and

(2) Other testing, monitoring or information gathering methods that produce information comparable to that produced by any method under subsection A of 20.2.70.408 NMAC or paragraph (1) of subsection B of 20.2.70.408 NMAC.

[11/30/95; 20.2.70.408 NMAC - Rn, 20 NMAC 2.70.408 06/14/02]

20.2.70.409 to 20.2.70.499 [RESERVED]

20.2.70.500 to 20.2.70.599 [RESERVED]

HISTORY OF 20.2.70 NMAC:
Pre NMAC History: The material in this part was derived from that previously filed with the commission of public records - state records center and archives.
EIB/AQCR 770, Air Quality Control Regulation 770 - Operating Permits, filed 11/15/93.

History of Repealed Material: [RESERVED]

Other History:
EIB/AQCR 770, *Air Quality Control Regulation 770 - Operating Permits, filed* 11/15/93 was **renumbered** into first version of the New Mexico Administrative Code as 20 NMAC 2.70, Operating Permits, filed 10/30/95;
20 NMAC 2.70, Operating Permits, filed 10/30/95 was **renumbered, reformatted and replaced** by 20.2.70 NMAC, Operating Permits, effective 06/14/02.

PART 72
CONSTRUCTION PERMITS

20.2.72.1 ISSUING AGENCY:

Environmental Improvement Board.
[20.2.72.1 NMAC - Rn, 20 NMAC 2.72.100, 2/2/01]

20.2.72.2 SCOPE:

All persons who intend to construct or modify a source, except as otherwise provided by this Part.
[20.2.72.2 NMAC - Rn, 20 NMAC 2.72.101, 2/2/01]

20.2.72.3 STATUTORY AUTHORITY:

Environmental Improvement Act, NMSA 1978, Section 74-1-8(A)(4) and Air Quality Control Act, NMSA 1978, Sections 74-2-1 et seq., including specifically, Section 74-2-7(A)(1), (B), (C) and (D).
[20.2.72.3 NMAC - Rn, 20 NMAC 2.72.102, 2/2/01]

20.2.72.4 DURATION:

Permanent. Notwithstanding the applicability provisions of 20.2.72.402 NMAC, the Department is stayed from enforcing requirements relating to asphalt fumes as a toxic air pollutant for new or modified sources until September 1, 1997.
[20.2.72.4 NMAC - Rn, 20 NMAC 2.72.103, 2/2/01]

20.2.72.5 EFFECTIVE DATE:

November 30, 1995 except where a later date is cited at the end of a section or paragraph.
[The latest effective date of any section in this Part is 9/6/06.]
[20.2.72.5 NMAC - Rn, 20 NMAC 2.72.104, 2/2/01]

20.2.72.6 OBJECTIVE:

The objective of this Part is to establish the requirements for obtaining a construction permit.
[20.2.72.6 NMAC - Rn, 20 NMAC 2.72.105, 2/2/01]

20.2.72.7 DEFINITIONS:

In addition to the terms defined in 20.2.2 NMAC (Definitions) as used in this Part:

A. **"Accelerated review"** means an optional process of permit application review that allows the Department to utilize a qualified outside firm to assist in review of a construction permit application.

B. **"Affiliate,"** for the purposes of accelerated review, means a person that directly or indirectly, through one or more intermediaries, controls or is under common control with another person.

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Control includes the possession of the power to direct or cause the direction of management and policies of a person, whether directly or indirectly through the ownership, control or holding with the power to vote ten percent or more of the person's voting securities.

C. **"Air pollution control equipment"** means any device, equipment, process or combination thereof the operation of which would limit, capture, reduce, confine, or otherwise control air contaminants or convert for the purposes of control any air contaminant to another form, another chemical or another physical state.

D. **"Ambient air"** means the outdoor atmosphere, but does not include the area entirely within the boundaries of the industrial or manufacturing property within which the air contaminants are or may be emitted and public access is restricted within such boundaries.

E. **"Coal mining operation"** means the business of developing, producing, preparing or loading bituminous coal, subbituminous coal, anthracite, or lignite, or of reclaiming the areas upon which such activities occur. This definition does not include coal preparation plants.

F. **"Coal preparation plant"** means any facility which prepares coal by one or more of the following processes: breaking, crushing, screening, wet or dry cleaning, and thermal drying.

G. **"Commencement"** means that an owner or operator has undertaken a continuous program of construction or modification.

H. **"Conflict of interest,"** for the purposes of accelerated review, means any direct or indirect relationship between the qualified outside firm and the applicant or other interested person that would cause a reasonable person with knowledge of the relevant facts to question the integrity or impartiality of the qualified outside firm in review of the application. A conflict of interest does not include any gifts, gratuities, financial or contractual relationship of less than one hundred dollars ($100) in value for the twelve month period preceding Department receipt of the application. A conflict of interest includes but is not limited to the following examples:

(1) Gifts or gratuities of value have been exchanged between the qualified outside firm and the applicant.

(2) The qualified outside firm has provided goods or services to the applicant within one year prior to the start, or during the term, of the accelerated review process.

(3) An express or implied contractual relationship exists between the qualified outside firm and the applicant and the qualified outside firm has provided goods or services to the applicant through that relationship within five years prior to the start of the accelerated review process.

(4) There is a current financial relationship between the qualified outside firm and the applicant. Current financial relationships include, but are not limited to:

(a) The qualified outside firm owes anything of value to, or is owed anything of value by the applicant.

(b) The qualified outside firm has provided goods or services to the applicant and has issued a warranty or guarantee for the work that is still in effect during the time the contracted work for accelerated review is being performed.

(5) A director, officer, or employee of the qualified outside firm, who will perform services under a contract pursuant to this section (20.2.72.221 NMAC), has one or more personal, business, or financial interests or relationships with the applicant or any director, officer or employee of the applicant which would cause a reasonable person with knowledge of the relevant facts to question the integrity or impartiality of those who are or will be acting under a contract.

(6) A director, officer or employee of the qualified outside firm was a director, officer or employee of the applicant within one year prior to the start of the accelerated review process.

(7) Except where allowed by the Department, communication has been made between the qualified outside firm and the applicant regarding the substance of the application before a qualified outside firm has been selected to perform accelerated review of an application. Direct communication between the qualified outside firm and the applicant may take place once the qualified outside firm has been selected by the Department.

(8) Any affiliate of the applicant has any of the above identified relationships with the qualified outside firm.

(9) Any affiliate of the qualified outside firm has any of the above identified relationships with the applicant.

(10) Any affiliate of the applicant has any of the above identified relationships with any affiliate of the qualified outside firm.

I. **"Construction"** means fabrication, erection, installation or relocation of a stationary source, including but not limited to temporary installations and portable stationary sources.

J. **"Emergency"** means unforeseen circumstances resulting in an imminent and substantial endangerment to health, safety, or welfare which requires immediate action.

K. **"Federally enforceable"** means all limitations and conditions which are enforceable by the administrator of the US EPA, including those requirements developed pursuant to 40 CFR Parts 60 and 61, requirements within any applicable State Implementation Plan, any permit requirements established pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR Part 51, Subpart I including 40 CFR 51.165 and 40 CFR 51.166.

L. **"Fugitive emissions"** means those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

M. **"Hazardous air pollutant"** means an air contaminant which has been classified as a "hazardous air pollutant" by the administrator of the US EPA and is subject to a NESHAP.

N. **"Interested person,"** as used in the definition of conflict of interest, means any person, other than the Department, that is reasonably expected to provide or has provided substantive comment or technical evidence on the permit application.

O. **"Malfunction"** means any sudden and unavoidable failure of air pollution control equipment, process equipment, or process to operate in an expected manner. Failures that are caused entirely or in part by poor maintenance, careless operation, or any other preventable equipment breakdown shall not be considered a malfunction.

P. **"Modification"** means any physical change in, or change in the method of operation of, a stationary source which results in an increase in the potential emission rate of any regulated air contaminant emitted by the source or which results in the emission of any regulated air contaminant not previously emitted, but does not include:

(1) a change in ownership of the source;

(2) routine maintenance, repair or replacement;

(3) installation of air pollution control equipment, and all related process equipment and materials necessary for its operation, undertaken for the purpose of complying with regulations adopted by the board or pursuant to the Federal Act; or

(4) unless previously limited by enforceable permit conditions:

(a) an increase in the production rate, if such increase does not exceed the operating design capacity of the source;

(b) an increase in the hours of operation; or

(c) use of an alternative fuel or raw material if, prior to January 6, 1975, the source was capable of accommodating such fuel or raw material, or if use of an alternate fuel or raw material is caused by any natural gas curtailment or emergency allocation or any other lack of supply of natural gas.

Q. **"National Ambient Air Quality Standard"** means, unless otherwise modified, the primary (health-related) and secondary (welfare-based) federal ambient air quality standards promulgated by the US EPA pursuant to Section 109 of the Federal Act.

R. **"National Emission Standards for Hazardous Air Pollutants"** or **"NESHAP"** mean the regulatory requirements, guidelines and emission limitations promulgated by the US EPA pursuant to Section 112 of the Federal Act.

S. **"New Source Performance Standard"** or **"NSPS"** means the regulatory requirements, guidelines and emission limitations promulgated by the US EPA pursuant to Section 111 of the Federal Act.

T. **"Nonattainment area"** means for any air contaminant an area which is shown by monitored data or which is calculated by air quality modeling (or other methods determined by the administrator to be reliable) to exceed any national or New Mexico ambient air quality standard for such contaminant. Such term includes any areas identified under Sub-paragraphs (A) through (C) of Section 107 (d)(1) of the Federal Act.

U. **"Operator"** means the person or persons responsible for the overall operation of a facility.

V. **"Owner"** means the person or persons who own a facility or part of a facility.

W. **"Part"** means an air quality control regulation under Title 20, Chapter 2 of the New Mexico Administrative Code, unless otherwise noted; as adopted or amended by the Board.

X. **"Portable stationary source"** means a source which can be relocated to another operating site with limited dismantling and reassembly, including for example but not limited to moveable sand and gravel processing operations and asphalt plants.

Y. **"Potential emission rate"** means the emission rate of a source at its maximum capacity to emit a regulated air contaminant under its physical and operational design, provided any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored or processed, shall be treated as part of its physical and operational design only if the limitation or the effect it would have on emissions is enforceable by the department pursuant to the Air Quality Control Act or the federal Act.

Z. **"Qualified outside firm"** means any person who has entered into a contract with the Department to provide assistance in the accelerated review of construction permit applications.

AA. **"Regulated air contaminant"** means, any air contaminant, the emission or ambient concentration of which is regulated pursuant to the New Mexico Air Quality Control Act or the Federal Act.

BB. **"Shutdown"** means the cessation of operation of any air pollution control equipment, process equipment or process for any purpose, except routine phasing out of batch process units.

CC. **"Standard Industrial Classification"** or **"SIC"** means the code from the classification manual created by the Executive Office of the President-Office of Management and Budget, which categorizes industrial, manufacturing and commercial facilities, as listed in the Standard Industrial Code Manual published by the U.S. Government Printing Office, Washington D.C. 1972.

DD. **"Startup"** means the setting into operation of any air pollution control equipment, process equipment or process for any purpose, except routine phasing in of batch process units.

EE. **"Stationary source"** or **"source"** means any building, structure, equipment, facility, installation (including temporary installations), operation or portable stationary source which emits or may emit any air contaminant. Any research facility may group its sources for the purpose of this Part at the discretion of the Secretary.

[20.2.72.7 NMAC - Rn, 20 NMAC 2.72.107, 2/2/01; A, 3/30/01; A, 2/18/02]

20.2.72.8 AMENDMENT AND SUPERSESSION OF PRIOR REGULATIONS:
This Part amends and supersedes Air Quality Control Regulation ("AQCR") 702 - Permits, filed May 29, 1990, as amended ("AQCR 702").

A. All references to AQCR 702 in any other rule shall be construed as a reference to this Part.

B. The amendment and supersession of AQCR 702 shall not affect any administrative or judicial enforcement action pending on the effective date of such amendment nor the validity of any permit issued pursuant to AQCR 702.
[20.2.72.8 NMAC - Rn, 20 NMAC 2.72.106, 2/2/01]

20.2.72.9 DOCUMENTS:
Documents incorporated and cited in this Part may be viewed at the New Mexico Environment Department, Air Quality Bureau, Harold Runnels Building, 1190 St. Francis Drive, Santa Fe, NM 87505.
[20.2.72.9 NMAC - Rn, 20 NMAC 2.72.108, 2/2/01]

20.2.72.10- 20.2.72.199 [RESERVED]

20.2.72.200 APPLICATION FOR CONSTRUCTION, MODIFICATION, NSPS, AND NESHAP - PERMITS AND REVISIONS:

A. Permits must be obtained from the Department by:

(1) Any person constructing a stationary source which has a potential emission rate greater than 10 pounds per hour or 25 tons per year of any regulated air contaminant for which there is a National or New Mexico Ambient Air Quality Standard. If the specified threshold in this subsection is exceeded for any one regulated air contaminant, all regulated air contaminants with National or New Mexico Ambient Air Quality Standards emitted are subject to permit review. Within this subsection, the potential emission rate for nitrogen dioxide shall be based on total oxides of nitrogen;

(2) Any person modifying a stationary source when all of the pollutant emitting activities at the entire facility, either prior to or following the modification, emit a regulated air contaminant for which there is a National or New Mexico Ambient Air Quality Standard with a potential emission rate greater than 10 pounds per hour or 25 tons per year and the regulated air contaminant is emitted as a result of the modification. If the specified threshold in this subsection is exceeded for any one regulated air contaminant, all regulated air contaminants with National or New Mexico Ambient Air Quality Standards emitted by the modification are subject to permit review. Within this subsection, the potential emission rate for nitrogen dioxide shall be based on total oxides of nitrogen;

(3) Any person constructing or modifying any source or installing any equipment which is subject to 20.2.77 NMAC (New Source Performance Standards), 20.2.78 NMAC (Emission Standards for Hazardous Air Pollutants), or any other New Mexico Air Quality Control Regulation which contains emission limitations for any regulated air contaminant;

(4) For toxic air pollutants, see 20.2.72.400 NMAC - 20.2.72.499 NMAC;

(5) Any person constructing a stationary source which has a potential emission rate for lead greater than 5 tons per year or modifying a stationary source which either prior to or following the modification has a potential emission rate for lead greater than 5 tons per year; or

(6) Sources which are major sources of hazardous air pollutants by the definitions in 20.2.83 NMAC (Construction or Modification of Major Sources of Hazardous Air Pollutants).

B. Fugitive dust emissions from a coal mining operation shall not be subject to the requirements of Paragraph 1 of Subsection A of 20.2.72.200 NMAC. Note: New coal mining operations are required to have an approved air pollution control plan for fugitive dust emissions by the New Mexico Surface Coal Mining Commission.

C. Any source or modification meeting the applicability requirements of this Part, but which is a major stationary source or a major modification as defined in 20.2.74 NMAC, shall in addition be subject to 20.2.74 NMAC (Prevention of Significant Deterioration).

D. Any source or modification meeting the applicability requirements of this Part but which is a major stationary source or a major modification as defined in 20.2.79 NMAC, shall in addition be subject to 20.2.79 NMAC (Permits - Nonattainment Areas).

E. For all sources subject to this Part, applications for permits shall be filed prior to the commencement of the construction, modification or installation. Regardless of the anticipated commencement date, no construction, modification or installation shall begin prior to issuance of the permit.

F. Temporary installations and portable stationary sources are subject to this Part.

G. If a source consists of more than one unit, a separate permit may be required for each unit which is not substantially interrelated with another unit. A common connection leading to ductwork, pollution control equipment or a single stack shall not, by itself, constitute a substantial interrelationship.

H. Any source which previously did not require a permit because it was in existence before August 31, 1972 shall be subject to the requirements of this Part if operations cease for a period of five years or more and the source has a potential emission rate greater than 10 pounds per hour or 25 tons per year of any regulated air contaminant for which there is a National or New Mexico Ambient Air Quality Standard.

I. Any source meeting the applicability requirements of this Part, but which is a major source of hazardous air pollutants, shall in addition be subject to 20.2.83 NMAC (Construction or Modification of Major Sources of Hazardous Air Pollutants).

[20.2.72.200 NMAC - Rn, 20 NMAC 2.72.II.200, 2/2/01]

20.2.72.201 NEW SOURCE REVIEW COORDINATION:

In cases where the new source review requirements of either 20.2.74 NMAC, 20.2.77 NMAC, 20.2.78 NMAC, 20.2.79 NMAC, or 20.2.83 NMAC (Construction or Modifications of Major Sources of Hazardous Air Pollutants) apply to a new stationary source or modification in addition to this Part, the following provisions apply:

A. Only one permit application shall be submitted. The applicant shall submit a sufficient number of copies to meet the requirement of the applicable Part which requires the most copies;

B. The application shall be ruled administratively complete when information required by all applicable Parts has been submitted;

C. Definitions and requirements of each applicable Part are applied separately and do not supersede each other; and

D. After the requirements of all applicable Parts are met, only one permit shall be issued.

[20.2.72.201 NMAC - Rn, 20 NMAC 2.72.II.201, 2/2/01]

20.2.72.202 EXEMPTIONS:

The following exemptions are made to the following requirements of 20.2.72.200 NMAC - 20.2.72.299 NMAC. The exemptions in this section do not apply to emissions of toxic air pollutants listed under 20.2.72.502 NMAC, do not alter the calculation of the potential emissions of toxic air pollutants for applicability under 20.2.72.402 NMAC, and do not exempt the Department or the owner or operator of any source from any requirement under 20.2.72.403 NMAC, 20.2.72.404 NMAC, or 20.2.72.405 NMAC.

A. The following sources and activities shall not be reported in the permit application. Emissions from such activities shall not be included in the calculation of facility-wide potential emission rate under Paragraphs 1 or 2 of Subsection A of 20.2.72.200 NMAC. Such activities may be commenced or changed without a permit or permit revision under 20.2.72.200 NMAC - 20.2.72.299 NMAC:

(1) Activities which occur strictly for maintenance of grounds or buildings, including: lawn care, pest control, grinding, cutting, welding, painting, woodworking, sweeping, general repairs, janitorial activities, and building roofing operations;

(2) Activities for maintenance of equipment or pollution control equipment, either inside or outside of a building, including cutting, welding, and grinding, but excluding painting;

(3) Exhaust emissions from forklifts, courier vehicles, front end loaders, graders, carts, maintenance trucks, and fugitive emissions from fleet vehicle refueling operations, provided such emissions are not subject to any requirements under this Chapter (Air Quality), NSPS or NESHAP;

(4) Use of fire fighting equipment and fire fighting training;

(5) Government military activities such as field exercises, explosions, weapons testing and demolition to the extent that such activities:

(a) Do not result in visible emissions entering publicly accessible areas; and

(b) Are not subject to a NSPS or NESHAP;

(6) Office activities, such as photocopying;

(7) Test drilling for characterization of underground storage tank and waste disposal sites;

(8) Non-anthropogenic wind blown dust;

(9) Residential activities such as use of fireplaces, woodstoves, and barbecue cookers;

(10) Gases used to calibrate plant instrumentation, including continuous emission monitoring (CEM) systems;

(11) Food service, such as cafeteria activities;

(12) Automotive repair shop activities, except painting and use of solvents;

(13) Use of portable aerospace ground equipment (such as power generators, compressors, heaters, air conditioners, lighting units) in direct support of aircraft operations and on or in the immediate vicinity of an airfield;

(14) Activities which occur strictly for preventive maintenance of highway bridges, displays and water towers, including: grinding, cutting, welding, painting, and general repairs;

(15) The act of repositioning or relocating equipment, pipes, ductwork, or conveyors within the plant site, but only when such change in physical configuration does not:

(a) Reposition or relocate any source of air emissions or the emission points from any such source; or

(b) Increase the amount of air emissions or the ambient impacts of such emissions.

B. The presence of the following new or modified sources and activities at the facility shall be reported as provided for in the permit application forms supplied by the Department. Emissions from such sources and activities shall not be included in the calculation of facility-wide potential emission rate under Paragraphs 1 or 2 of Subsection A of 20.2.72.200 NMAC. Construction of such sources or commencement of such activities after issuance of the permit shall be subject to the administrative permit revision procedures in 20.2.219 NMAC.

(1) Fuel burning equipment which is used solely for heating buildings for personal comfort or for producing hot water for personal use and which:

(a) Uses gaseous fuel and has a design rate less than or equal to five (5) million BTU per hour; or

(b) Uses distillate oil (not including waste oil) and has a design rate less than or equal to one (1) million BTU per hour;

(2) *VOC emissions resulting from the handling or storing of any VOC if:*

(a) Such VOC has a vapor pressure of less than two tenths (0.2) PSI at temperatures at which the compound is stored and handled; and

(b) The owner or operator maintains sufficient record keeping to verify that the requirements of Sub-paragraph (a) of this paragraph are met;

(3) Standby generators which are:

(a) Operated only during the unavoidable loss of commercial utility power;

(b) Operated less than 500 hours per year; and

(c) Either are:

i. The only source of air emissions at the site; or

ii. Accompanied by sufficient record keeping to verify that the standby generator is operated less than 500 hours per year;

(4) The act of repositioning or relocating sources of air emissions or emissions points within the plant site, but only when such change in physical configuration does not increase air emissions or the ambient impacts of such emissions;

(5) Any emissions unit, operation, or activity that has a potential emission rate of no more than one-half (1/2) ton per year of any pollutant for which a National or New Mexico Ambient Air Quality Standard has been set or one-half (1/2) ton per year of any VOC. Multiple emissions units, operations, and activities that perform identical or similar functions shall be combined in determining the applicability of this exemption;

(6) Surface coating of equipment, including spray painting, roll coating, and painting with aerosol spray cans, if:

(a) The potential emission rate of VOCs do not exceed ten (10) pounds per hour;

(b) The facility-wide total VOC content of all coating and clean-up solvent use is less than two (2) tons per year; and

(c) The owner or operator maintains sufficient record keeping to verify that the requirements in Sub-paragraphs (a) and (b) of this paragraph are met;

(7) Particulate emissions resulting from abrasive blasting operations, if:

(a) Blasting operations are entirely enclosed in a building; and

(b) No visible particulate emissions are released from the building.

C. For sources and units subject to 40 CFR Part 60 (NSPS), 40 CFR Part 61 (NESHAP) or other Parts of this Chapter (Air Quality), except 40 CFR Part 60 Subparts I (asphalt plants) and OOO (rock crushers), 40 CFR Part 61 Subpart C (Beryllium), and 40 CFR Part 61 Subpart D (Beryllium *Rocket Motor Firing):*

(1) Such sources and units shall be exempt from the applicability requirements in Paragraph 3 of Subsection A of 20.2.72.200 NMAC if such sources or units:

(a) Are included in a Notice of Intent filed under 20.2.73 NMAC (Notice of Intent and Emissions Inventory); or

(b) Have met the notification requirements to which they are subject under NSPS or NESHAP; and

(2) Applicability determinations under Paragraphs 1 and 2 of Subsection A of 20.2.72.200 NMAC shall take into account all federally enforceable emission limits established for such sources or units under NSPS, NESHAP and other Parts of this Chapter.

D. Portable Source Relocation. For a portable source which has been issued a permit under this Part:

(1) Such source may relocate without undergoing a permit revision if:

(a) The source is installed in a manner conforming with the initial permit;

(b) The source continues to meet all applicable emission limitations and permit conditions; and

(c) The source meets the applicable requirements in Paragraphs 2 and 3 of Subsection D of 20.2.72.202 NMAC below;

(2) For each portable compressor engine which has been issued a streamlined permit in accordance with Paragraph 1 of Subsection D of 20.2.72.301 NMAC, the owner or operator shall complete the appropriate forms provided by the Department and maintain such records on file for at least two (2) years;

(3) For all other portable sources, including but not limited to rock crushers and asphalt plants:

(a) The owner or operator shall notify the Department, on the form provided by the Department, at least fifteen (15) days prior to beginning installation at the new location;

(b) Operation at a new location of such source shall not commence until the Department has approved the relocation in writing;

(c) The Department shall not approve the relocation if it would result in exceedances of any National or New Mexico Ambient Air Quality Standard at the new location; and

(d) The Department shall approve, deny, or approve with conditions, the relocation request within fifteen (15) days of receipt of the notice form.

[20.2.72.202 NMAC - Rn, 20 NMAC 2.72.II.202, 2/2/01]

20.2.72.203 CONTENTS OF APPLICATIONS:

A. Any person seeking a permit under Subsection A of 20.2.72.200 NMAC shall do so by filing a written application with the Department. The applicant shall submit the number of copies of the permit application specified in the applicable application form. The items of this section, if requested on the applicable application form, are required before the Department may deem an application administratively complete. The items may be modified by the Department, as appropriate, for emergency permits processed under 20.2.72.215 NMAC. All applications shall, as required by the Department:

(1) Be filled out on the form(s) furnished by the Department;

(2) State the applicant's name and address, together with the names and addresses of all owners or operators of the source, and the applicant's state of incorporation or principal registration to do business;

(3) Provide all information, including all calculations and computations, to describe the specific chemical and physical nature and to estimate the maximum quantities of any regulated air contaminants the source will emit through routine operations after construction, modification or installation is completed, and estimate maximum potential emissions during malfunction, startup, shutdown. With respect to a toxic air pollutant as defined by Subsection H of 20.2.72.401 NMAC this requirement only applies when the toxic air pollutant is emitted in such a manner that a permit is required under the provisions of 20.2.72.400 NMAC - 20.2.72.499 NMAC;

(4) Contain a regulatory compliance discussion demonstrating compliance with each applicable air quality regulation, ambient air quality standard, prevention of significant deterioration increment, and provision of 20.2.72.400 NMAC - 20.2.72.499 NMAC. The discussion must include an analysis, which may require use of US EPA-approved air dispersion model(s), to (1) demonstrate that emissions from routine operations will not violate any New Mexico or National Ambient Air Quality Standard or prevention of significant deterioration increment, and (2) if required by 20.2.72.400 NMAC - 20.2.72.499 NMAC, estimate ambient concentrations of toxic air pollutants.

(5) Provide a preliminary operational plan defining the measures to be taken to mitigate source emissions during malfunction, startup or shutdown;

(6) Include a topographical map, at least as detailed as the 7.5 minute Topographic Quadrangle map published by the United States Geological Survey, showing the exact location and geographical coordinates of the proposed construction, modification or installation of the source;

(7) Include a process flow sheet, including a material balance, and a site diagram of all components and locations of emissions to the atmosphere of the facility which would be involved in routine operations and emissions;

(8) Include a full description, including all calculations of controlled and uncontrolled emissions and the basis for all control efficiencies presented, of the equipment to be used for air pollution control, including a process flow sheet, or, if the Department so requires, layout and assembly drawings;

(9) Include a description of the equipment or methods proposed by the applicant to be used for emission measurement;

(10) State the maximum and standard operating schedules of the source after completion of construction, modification or installation or after permit revision in terms of which and how many hours per day, days per week, days per month and days per year;

(11) Contain such other specifically identified relevant information as the Department may reasonably require;

(12) Be notarized and signed under oath or affirmation by the operator, the owner or an authorized representative, certifying, to the best of his or her knowledge, the truth of all information in the application and addenda, if any;

(13) Contain payment of any fees which are specified in 20.2.75 NMAC (Construction Permit Fees) as payable at the time the application is submitted;

(14) Contain documentary proof of applicant's public notice, if applicable, as specified in Subsection B of 20.2.72.203 NMAC; and

(15) At the sole discretion of the applicant, contain a request for accelerated review of the application.

B. The applicant's public notice for technical permit revisions shall be as specified in Paragraph 6 of Subsection B of 20.2.72.219 NMAC. The applicant's public notice for a permit or significant permit revision shall be:

(1) Provided by certified mail, to the owners of record, as shown in the most recent property tax schedule, of all properties:

(a) Within one hundred (100) feet of the property on which the facility is located or proposed to be located, if the facility is or is proposed to be located in a Class A or Class H county or a municipality with a population of more than two thousand five hundred (2500) persons; or

(b) Within one-half (1/2) mile of the property on which the facility is located or is proposed to be located if the facility is or will be in a county or municipality other than those specified in Sub-paragraph (a) of Paragraph 1 of Subsection B of 20.2.72.203 NMAC;

(2) Provided by certified mail to all municipalities and counties in which the facility is or will be located and to all municipalities, Indian tribes, and counties within a ten (10) mile radius of the property on which the facility is proposed to be constructed or operated;

(3) Published once in a newspaper of general circulation in each county in which the property on which the facility is proposed to be constructed or operated is located. This notice shall appear in either the classified or legal advertisements section of the newspaper and at one other place in the newspaper calculated to give the general public the most effective notice and, when appropriate, shall be printed in both English and Spanish;

(4) Posted in at least four (4) publicly accessible and conspicuous places, including:

(a) The proposed or existing facility entrance on the property on which the facility is, or is proposed to be, located, until the permit or significant permit revision is issued or denied; and

(b) Three (3) locations commonly frequented by the general public, such as a nearby post office, public library, or city hall; and

(5) Submitted as a public service announcement to at least one radio or television station which serves the municipality or county in which the source is or is proposed to be located.

C. The notice specified in Paragraphs 1 through 4 of Subsection B of 20.2.72.203 NMAC shall contain the following:

(1) The applicant's name and address, together with the names and addresses of all owners or operators of the facility or proposed facility;

(2) The actual or estimated date that the application was or will be submitted to the Department;

(3) The exact location of the facility or proposed facility;

(4) A description of the process or change for which a permit is sought, including an estimate of the maximum quantities of any regulated air contaminant the source will emit after proposed construction is complete or permit is issued;

(5) The maximum and standard operating schedules of the facility after completion of proposed construction or permit issuance; and

(6) The current address of the Department to which comments and inquiries may be directed.

D. The public service announcement request specified in Paragraph 5 of Subsection B of 20.2.72.203 NMAC shall contain the following information about the facility or proposed facility:

(1) The name, location, and type of business;

(2) The name of the principal owner or operator;

(3) The type of process or change for which a permit is sought;

(4) Locations where the notices required under Paragraph 4 of Subsection B of 20.2.72.203 NMAC have been posted; and

(5) The address or telephone number at which comments and inquires may be directed to the Department.

E. Changing, Supplementing or Correcting Applications:

(1) Prior to a final decision on an application, the applicant shall have a duty to promptly supplement and correct information submitted in the application. The duty to supplement shall include relevant information thereafter acquired or otherwise determined to be relevant.

(2) If, while processing an application, regardless of whether it has been determined to be

administratively complete, the Department determines that additional information is necessary to evaluate or take final action on that application, it may request such information. The request shall be in writing, identify the additional information requested and the need for the additional information, and set a reasonable deadline for a response. The applicant shall submit the requested information in writing on or before the deadline set by the Department.
[20.2.72.203 NMAC - Rn, 20 NMAC 2.72.II.203, 2/2/01; A, 3/30/01]

20.2.72.204 CONFIDENTIAL INFORMATION PROTECTION:
All confidentiality claims made regarding material submitted to the Department under this Part shall be reviewed under the provisions of 20.2.1 NMAC (General Provisions).
[20.2.72.204 NMAC - Rn, 20 NMAC 2.72.II.204, 2/2/01]

20.2.72.205 CONSTRUCTION, MODIFICATION AND PERMIT REVISION IN BERNALILLO COUNTY:
For the construction or modifications of sources within Bernalillo County, the applicant shall make such applications to the air quality control staff of the joint Albuquerque-Bernalillo County Air Quality Control Board, unless that board loses, rejects or fails to exercise authority for the administration and enforcement of the Air Quality Control Act, at which time this Part shall apply in full in Bernalillo County.
[20.2.72.205 NMAC - Rn, 20 NMAC 2.72.II.205, 2/2/01]

20.2.72.206 PUBLIC NOTICE AND PARTICIPATION:

A. The Department shall:

(1) Make available for public inspection a list of all pending applications for permits or permit revisions;

(2) Make available for public inspection the permit application and the Department's preliminary determination. This material shall be available both at the Department's central office and the district or field office nearest to the proposed source. Copies of any permit application, except those portions of which may be determined as confidential in accordance with 20.2.1 NMAC (General Provisions), will be supplied upon written request and payment of reasonable costs;

(3) Subsequent to an affirmative administrative completeness determination, publish a public notice in a newspaper of general circulation in the area closest to the location of the source. The notice shall include: the applicant's name and address, the location and brief description of the source, a summary of estimated emissions and ambient impact, and the Department's preliminary intent to issue the permit if the construction or modification requested in the application will comply with air quality requirements, including ambient standards. The notice shall identify the location of the permit application and Department's Analysis (when available) for public review and describe the manner in which comments or evidence may be submitted to the Department, including that persons must inform the Department in writing of their interest in the permit application in order to have a 30 day period to review and comment on the analysis under Subsection B of 20.2.72.206 NMAC below. The notice shall clearly state that any person who does not express such interest in writing prior to the end of the initial 30 day comment period will not receive notification of the availability of the analysis and thus forewarn such person of the need to express interest in writing if they desire to review and comment on the analysis;

(4) Provide the notice under Paragraph 3 of Subsection A of 20.2.72.206 NMAC above by mail, which may include electronic mail, to all individuals and organizations identified on a list maintained by the Department of those who have indicated in writing a desire to receive notices of all applications under this Part;

(5) Allow all interested persons thirty (30) days from the date the public notice is published to express an interest in writing in the permit application;

(6) Mail written notice of the action taken on a permit application to any person who expresses an interest in writing in the application; and

(7) Mail a copy of the public notice at the same time it is sent for publication to the appropriate agency in the following locations if the source will locate within fifty kilometers of the boundary of other states, Bernalillo County, or a Class I area. Copies of all public notices shall be sent to US EPA Region VI, if requested by US EPA.

B. In the event that any person expresses an interest in writing in the permit application, the Department shall also:

(1) Notify each person who expressed an interest in writing in the permit application of the date and the location that the Department's Analysis was or will be available for review; and

(2) Not issue the permit until at least thirty (30) days after the Department's Analysis is available for review. During this thirty (30) day period, any person may submit written public comments or request a public hearing.

C. The Department shall hold a public hearing if the Secretary determines that there is a significant public interest. Public hearings shall be held in the geographic area likely to be impacted by the source. The time, date, and place of the hearing shall be determined by the Department. The Department shall give notice of the hearing to the applicant and the public. The Secretary may appoint a hearing officer. A transcript of the hearing shall be made at the request of either the Department or the applicant and at the expense of the person requesting the transcript. At the hearing, all interested persons shall be given a reasonable chance to submit data, views or arguments orally or in writing and to examine witnesses testifying at the hearing.

[20.2.72.206 NMAC - Rn & A, 20 NMAC 2.72.II.206, 2/2/01]

20.2.72.207 PERMIT DECISIONS AND APPEALS:

A. The Department shall, within thirty (30) days after its receipt of an application for a permit or significant permit revision, review such application and determine whether it is administratively complete. If the application is deemed:

(1) *administratively complete, a letter to that effect shall be sent by certified mail to the* applicant.

(2) administratively incomplete, a letter shall be sent by certified mail to the applicant stating what additional information or points of clarification are necessary to deem the application administratively complete. Upon receipt of the additional information or clarification, the Department shall promptly review such information and determine whether the application is administratively complete.

(3) administratively complete but no permit is required, a letter shall be sent by certified mail to the applicant informing the applicant of the determination.

B. The Department shall either grant, grant subject to conditions or deny the permit or significant permit revision:

(1) *within ninety (90) days after the Department deems the application administratively*

complete, if the application is not subject to the requirements of 20.2.74 NMAC (Prevention of Significant Deterioration); or

(2) within one hundred eighty (180) days after the Department deems the application administratively complete, if the application is subject to the requirements of 20.2.74 NMAC (Prevention of Significant Deterioration).

C. If the Department fails to take action on the application within the deadlines specified in Subsection B of 20.2.72.207 NMAC, the Department shall notify the applicant by certified mail that an extension of time is necessary to process the application and shall specify, in detail, the grounds for the extension. The Secretary may grant an extension, not to exceed ninety (90) days, to the deadlines specified in Subsection B of 20.2.72.207 NMAC, if the Secretary determines that good cause exists for the extension. The Secretary shall notify the applicant by certified mail of the decision on the extension. If the Secretary grants the extension, the notification shall include the length of the extension and the reasons therefore. The authority under this paragraph may be delegated by the Secretary only to the Deputy Secretary or a Division Director. Examples of good cause for extension include, but are not limited to:

(1) the need to have public hearings;

(2) a health assessment is required under 20.2.72.400 NMAC - 20.2.72.499 NMAC;

(3) the permit application is subject to the requirements of 20.2.79 NMAC (Permits - Nonattainment Areas);

(4) additional time is needed to complete the requirements for federal review specified in 20.2.74.403 NMAC;

(5) the permit application requires review of unusually complex technical and regulatory issues; or

(6) the Department is unable to complete review of information submitted, because of the timing and scope of the submittal.

D. The Department shall grant the permit, grant the permit subject to conditions, or deny the permit based on information contained in the Department's administrative record. The administrative record shall consist of the application, any other evidence submitted by the applicant, any evidence or written comments submitted by interested persons, any other evidence considered by the Department, a statement of matters officially noticed, and if a public hearing is held, the evidence submitted at the hearing. The applicant has the burden of demonstrating that a permit or permit revision should be approved.

E. Any person who participated in a permitting action before the Department shall be notified by the Department of the action taken and the reasons for the action. Notification of the applicant shall be by certified mail.

F. Any person who participated in a permitting action before the Department and who is adversely affected by such permitting action may file a petition for hearing before the board. The petition shall be made in writing to the board within thirty (30) days from the date notice is given of the Department's action and shall specify the portions of the permitting action to which the petitioner objects, certify that a copy of the petition has been mailed or hand-delivered as required by this paragraph, and attach a copy of the permitting action for which review is sought. Unless a timely request for hearing is made, the decision of the Department shall be final. The petition shall be copied simultaneously to the Department upon receipt of the appeal notice. If the petitioner is not the applicant or permittee, the petitioner shall mail or hand-deliver a copy of the petition to the applicant or permittee. The Department shall certify the administrative record to the board.

G. If a timely request for a hearing is made, the board shall hold a hearing within sixty (60) days of receipt of the petition in accordance with Section 74-2-7 of the New Mexico Air Quality Control Act, NMSA 1978.

H. Any person adversely affected by an administrative action taken by the board may appeal in accordance with Section 74-2-9 of the New Mexico Air Quality Control Act, NMSA 1978.
[20.2.72.207 NMAC - Rn, 20 NMAC 2.72.II.207, 2/2/01]

20.2.72.208 BASIS FOR DENIAL OF PERMIT:

The Department shall deny any application for a permit or permit revision if considering emissions after controls:

A. It appears that the construction, modification or permit revision will not meet applicable regulations adopted pursuant to the Air Quality Control Act;

B. The source will emit a hazardous air pollutant or an air contaminant in excess of any applicable New Source Performance Standard or National Emission Standard for Hazardous Air Pollutants or a regulation of the board;

C. For toxic air pollutants, see 20.2.72.400 NMAC - 20.2.72.499 NMAC;

D. The construction, modification, or permit revision will cause or contribute to air contaminant levels in excess of any National Ambient Air Quality Standard or New Mexico Ambient Air Quality Standard unless the ambient air impact is offset by meeting the requirements of either 20.2.79 NMAC or 20.2.72.216 NMAC, whichever is applicable;

E. The construction, modification, or permit revision would cause or contribute to ambient concentrations in excess of a Prevention of Significant Deterioration (PSD) increment;

F. Any provision of the Air Quality Control Act will be violated;

G. It appears that the construction of the new source will not be completed within a reasonable time; or

H. The Department chooses to deny the application due to a conflict of interest in accelerated review as provided for under Subsection C of 20.2.72.221 NMAC.
[20.2.72.208 NMAC - Rn, 20 NMAC 2.72.II.208, 2/2/01; A, 3/30/01]

20.2.72.209 ADDITIONAL LEGAL RESPONSIBILITIES ON APPLICANTS:

The issuance of a permit does not relieve any person from civil or criminal liability for failure to comply with the provisions of the Air Quality Control Act, the Federal Act, federal regulations thereunder, any applicable regulations of the board, and any other applicable law or regulation.
[20.2.72.209 NMAC - Rn, 20 NMAC 2.72.II.209, 2/2/01]

20.2.72.210 PERMIT CONDITIONS:

A. The contents of the application specifically identified by the Department shall become terms and conditions of the permit or permit revision.

B. The Department shall, as appropriate, specify conditions upon a permit, including:

(1) Placement of individual emission limits determined on a case-by-case basis on the source for which the permit is issued, but such individual emission limits shall be only as restrictive as the more stringent of the following:

(a) The extent necessary to meet the requirements of the Air Quality Control Act and the Federal Act; or

(b) The emission rate specified in the permit application;

(2) A requirement that such source install and operate control technology, determined on a case-by-case basis, sufficient to meet the requirements of the Air Quality Control Act and the Federal Act and regulations promulgated under either;

(3) Compliance with applicable NSPS and NESHAP;

(4) Imposition of reasonable restrictions and limitations other than restrictions and limitations relating to emission limits or emission rates; or

(5) Any combination of the above;

(6) In the case of a modification, the requirements of Subsection B of 20.2.72.210 NMAC apply only to the facility or facilities involved in such modification.

C. The Department may impose such other reasonable conditions upon a permit, including a schedule of construction, a condition requiring timely revision of permit terms or conditions in order to meet new requirements, if any, under any federally required and approved State Implementation Plan revision, and conditions requiring the source to be provided with or to undertake:

(1) Sampling ports of a size, number and location as the Department may require;

(2) Safe access to each port;

(3) Instrumentation to monitor and record emission data including continuous emission monitoring, if appropriate;

(4) Any other reasonable sampling, testing and ambient monitoring and meteorological facilities and protocols; and

(5) Periodic testing pursuant to 20.2.72.213 NMAC.

D. Any term or condition imposed by the Department on a permit or permit revision is enforceable to the same extent as a regulation of the board.

E. The Department will as a condition of each permit require the permittee to establish and maintain such records of the nature and amount of emissions and to make such periodic reports to the Department regarding the nature and amounts of emissions and the performance of air pollution control equipment, as are necessary to carry out the purpose of the Air Quality Control Act.

F. **[RESERVED]**

[20.2.72.210 NMAC - Rn, 20 NMAC 2.72.II.210, 2/2/01]

20.2.72.211 PERMIT CANCELLATIONS:

A. The Department shall automatically cancel any permit for any source which ceases operation for five years or more, or permanently. Reactivation of any source after the five year period shall require a new permit.

B. The Department may cancel a permit if the construction or modification is not commenced within two years from the date of issuance or, if during the construction or modification, work is suspended for a total of one year, such cancellation shall be subject to the following procedures:

(1) At least thirty days prior to the cancellation of a permit, the Department shall notify the permittee by certified mail of the impending cancellation. The Department shall notify the permittee by certified mail of the cancellation of his permit and the reasons therefor. Construction, modification and, if required, interim operation shall cease upon the effective date of cancellation contained in the notice of cancellation. A permittee who has received notice that a permit is or will be cancelled may request a hearing before the board. The request must be made in writing to the board within thirty days after notice of the Department's action has been received by the permittee. Unless a timely request for hearing is made, the decision of the Department shall be final; and

(2) If a timely request for hearing is made, the board shall hold a hearing within thirty days

after receipt of the request. The Department shall notify the permittee by certified mail of the date, time and place of the hearing. In the hearing the burden of proof shall be upon the permittee. The board may *designate a hearing officer to take evidence in the hearing. Based upon the evidence presented at the* hearing, the board shall sustain, modify or reverse the action of the Department.
[20.2.72.211 NMAC - Rn, 20 NMAC 2.72.II.211, 2/2/01]

20.2.72.212 PERMITTEE'S NOTIFICATION REQUIREMENTS TO DEPARTMENT:
Any owner or operator subject to this Part shall notify the Department in writing of or provide the Department with:

A. Anticipated date of initial startup of a source not less than thirty (30) days prior to the date;

B. Actual date of initial startup of a source within fifteen (15) days after the startup date;

C. Any change of operators within fifteen (15) days of such change;

D. Any necessary update or correction no more than sixty (60) days after the operator knows or should have known of the condition necessitating the update or correction of the permit.
[20.2.72.212 NMAC - Rn, 20 NMAC 2.72.II.212, 2/2/01]

20.2.72.213 STARTUP AND FOLLOWUP TESTING:
Within sixty (60) days after achieving the maximum production rate at which the source will be operated but not later than one hundred eighty (180) days after initial startup of the source, the owner or operator of the source may be required to conduct a performance test. The test method utilized shall be approved by the Department. Whenever the requirements of 40 CFR 60 or 61 apply, test methods must be utilized as specified in those regulations. The owner or operator shall notify the Department at least thirty (30) days prior to the test date and allow a representative of the Department to be present at the test. A written report of the results of the test shall be submitted to the Department by the owner or operator within thirty (30) days from the test date. This requirement may be reimposed on a source as necessary if inspections of the source indicate noncompliance with permit conditions subject to such testing, or the previous test showed noncompliance or was technically unsatisfactory. In such cases, the test requirement may be reimposed as frequently as necessary until compliance is achieved and testing is performed in a technically satisfactory manner. This testing requirement may be waived if the source is a member of a class subject to an exemption from this requirement pursuant to 20.2.72.214 NMAC, and has agreed to comply with, and its permit contains, enforceable design, operational and locational protocols set by the Department for the class of sources to which the source belongs.
[20.2.72.213 NMAC - Rn, 20 NMAC 2.72.II.213, 2/2/01]

20.2.72.214 SOURCE CLASS EXEMPTION PROCESS (PERMIT STREAMLINING):

A. Upon application by any person or group of persons, or upon the initiative of the Department, the board may exempt any source or class of sources, from any procedural requirement of this Part except the requirement to obtain a permit prior to commencement of construction if the board finds that the conditions set forth below in this section have been met. When possible, comprehensive exemptions shall be established for source classes in order to conduct expedited, streamlined permit processing for any applicant whose source is a member of such class. Exemptions may be granted only after a public hearing of the board, at which time the basis for such exemption shall be presented and any interested person allowed to comment and to question any witness. The board's decision that an exemption under this section is justified shall be based at a minimum on each of the following findings:

(1) The Department has substantial actual experience with or knowledge of the specific class of sources proposed for exemption, that such experience or knowledge is material to the application for exemption, and that such experience or knowledge includes modeling and analysis of a representative sample of such sources. Such knowledge may be acquired through, but not limited to, direct Department experience with such sources, or the review of other regulatory agencies' experience, records, documentation and formal actions, or through publications of professional organizations and societies *upon which engineers and scientists would conventionally rely in formulating a professional judgment*;

(2) The sources possess sufficiently common characteristics of operation, process technology, emissions, emission control technology and impact on air quality that with respect to the specific requirements proposed to be exempted, protocols have been developed which, if applied to all members of that class, will ensure that air quality is protected at least as well as would be accomplished by the full permit review process; and

(3) Under such an exemption, compliance with all federal and state air quality laws, regulations, standards and emissions limitations will be assured.

B. Exemptions may apply statewide or regionally and may be revoked by the board only after a public hearing following at least sixty days public notice.

C. As may be required under federal law, all protocols established hereunder shall be submitted to the US EPA for review and approval as revisions to the State Implementation Plan. Such protocols shall be established contingent upon approval by the US EPA.

D. There shall be no exemptions under this section from the requirements of 20.2.74 NMAC, 20.2.77 NMAC, 20.2.78 NMAC, or 20.2.79 NMAC.

[20.2.72.214 NMAC - Rn, 20 NMAC 2.72.II.214, 2/2/01]

20.2.72.215 EMERGENCY PERMIT PROCESS:

A. The Department may issue an emergency permit when the Secretary determines an emergency exists which threatens the public health, safety or welfare, and which requires the rapid construction or modification of, or installation of equipment in, a facility subject to this Part in order to mitigate, prevent or remedy such emergency.

B. Department personnel shall verify that the source, operating in accordance with the permit issued, can and will meet all applicable standards, emissions limitations and conditions before authorizing start-up in order to ensure that the public emergency is not worsened by excess or improperly controlled air pollution.

C. An emergency caused by any negligent or unlawful action or operation of the facility or the facility owner or operator, including but not limited to failure to apply timely for a permit or revision, shall not constitute an emergency for the purposes of this section.

D. The requirements of Paragraphs 5 and 6 of Subsection A of 20.2.72.206 NMAC, Subsection C of 20.2.72.206 NMAC, and Subsections A and B of 20.2.72.207 NMAC shall not apply to emergency permits processed under this section.

E. Construction shall not commence until the emergency permit is issued.

[20.2.72.215 NMAC - Rn & A, 20 NMAC 2.72.II.215, 2/2/01]

20.2.72.216 NONATTAINMENT AREA REQUIREMENTS:

A. The requirements of this section apply to:

(1) *a new source or modification of an existing source that will emit a regulated air* contaminant such that the ambient impact of the contaminant would exceed the significant ambient concentration in 20.2.72.500 NMAC, table 1, at any location that does not meet the New Mexico ambient air quality standard for the contaminant;

(2) a new source or modification of an existing source that is not a major stationary source or major modification as defined in 20.2.79 NMAC and that will emit a regulated air contaminant such that the ambient impact of the contaminant would exceed the significant ambient concentration in table 1 at any location that does not meet the national ambient air quality standard for the contaminant ; or

(3) an existing source that does not propose an increase in emissions and that will emit a regulated air contaminant such that the ambient impact of the contaminant would exceed the significant *ambient concentration in 20.2.72.500 NMAC (table 1) at any location that does not meet the national or* New Mexico ambient air quality standard for the contaminant.

B. A new source or modification of an existing source subject to this section shall offset the ambient impact of its emissions by:

(1) obtaining emission offsets for proposed emissions in an amount greater than one-to-one such that a net air quality benefit will occur; and

(2) ensuring emission offsets are quantifiable, enforceable, and permanent by meeting the following sections of 20.2.79 NMAC:

(a) 20.2.79.114 NMAC (emission offset baseline);

(b) 20.2.79.115 NMAC (emission offsets); and

(c) 20.2.79.117 NMAC *(air quality benefit).*

C. An existing source that is subject to this section shall demonstrate a net air quality benefit of at least a 20 percent reduction in ambient impact for each applicable contaminant. The 20 percent reduction shall be calculated as the projected source impact subtracted from the existing source impact divided by the existing source impact. The net air quality benefit must also meet the requirements of 20.2.79.117 NMAC (air quality benefit).

[20.2.72.216 NMAC - Rn, 20 NMAC 20.2.72.II.216, 2/2/01; A, 9/6/06]

20.2.72.217 COMPLIANCE CERTIFICATIONS:

A. Notwithstanding any other provision in the New Mexico State Implementation Plan approved by the Administrator, for the purpose of determining compliance, an owner or operator is not prohibited from using monitoring as required under 20.2.70 NMAC and incorporated into an operating permit in addition to any specified compliance methods.

B. *The requirements of this section are only applicable to those sources which, in addition* to being subject to this Part are either: defined as a major source under 20.2.70 NMAC (Operating Permits), or; subject to 20.2.82 NMAC (Maximum Achievable Control Technology Standards for Source Categories of Hazardous Air Pollutants).

[20.2.72.217 NMAC - Rn, 20 NMAC 20.2.72.II.217, 2/2/01]

20.2.72.218 ENFORCEMENT:

Notwithstanding any other provision in the New Mexico State Implementation Plan approved by the Administrator, any credible evidence may be used for the purpose of establishing whether a person has violated or is in violation of the terms or conditions of a permit issued pursuant to this Part, including permits for sources meeting the applicability requirements 20.2.74 NMAC (Prevention of Significant Deterioration), or 20.2.79 NMAC (Permits - Nonattainment Areas).

A. Information from the use of the following methods is presumptively credible evidence of whether a violation has occurred at the source:

(1) A monitoring or information gathering method approved for the source pursuant to 20.2.70 NMAC and incorporated in an operating permit; or

(2) Compliance methods specified in the New Mexico State Implementation Plan.

B. The following testing, monitoring or information gathering methods are presumptively credible testing, monitoring or information gathering methods:

(1) Any federally enforceable monitoring or testing methods, including those in 40 CFR, parts 51, 60, 61 and 75; and

(2) Other testing, monitoring or information gathering methods that produce information comparable to that produced by any method in Subsection A of 20.2.72.218 NMAC or Paragraph 1 of Subsection B of 20.2.72.218 NMAC, above.

C. The requirements of this section are only applicable to those sources which, in addition to being subject to this Part, are either: defined as a major source under 20.2.70 NMAC (Operating Permits), or; subject to 20.2.82 NMAC (Maximum Achievable Control Technology Standards for Source Categories of Hazardous Air Pollutants).

[20.2.72.218 NMAC - Rn, 20 NMAC 20.2.72.II.218, 2/2/01]

20.2.72.219 PERMIT REVISIONS:

A. Administrative Permit Revisions:

(1) Administrative permit revision procedures may be used only for those permit revisions that:

(a) Correct typographical errors;

(b) Provide for a minor administrative change at the source, such as a change in ownership or a change in the address or phone number of any person identified in the permit;

(c) Incorporate a change in the permit solely involving the retiring of a source or closing of a facility upon notification of the Department that the permittee has ceased operations of the source or facility;

(d) Incorporate a change in the permit solely involving the deletion from the permit of a source or sources upon notification of the Department that the source or sources have not been and will not be built; or

(e) Incorporate a source or activity at the facility which is exempted under Subsection B of 20.2.72.202 NMAC;

(2) The permittee shall apply for an administrative permit revision by filing a certified written notification of the proposed revision with the Department which includes all information required by the Department to review the request. The certification shall be made as required under Paragraph 12 of Subsection A of 20.2.72.203 NMAC;

(3) The administrative permit revision is effective upon receipt of the notification by the Department;

(4) Administrative permit revisions shall not be subject to public notification requirements under Subsection B of 20.2.72.203 NMAC and 20.2.72.206 NMAC. The Department shall attach the revision to the permit;

(5) Administrative permit revisions shall not be subject to filing fees or permit fees under 20.2.75 NMAC (Construction Permit Fees);

(6) The Department is not required to reissue the permit to incorporate an administrative permit revision.

B. Technical Permit Revisions:

(1) Technical permit revision procedures may be used only for:

(a) Permit revisions that incorporate a change in the permit solely involving a change to monitoring, record keeping, or reporting requirements by the permittee, provided that the Department determines that such change does not reduce the enforceability of the permit;

(b) Permit revisions that incorporate a change in the permit solely involving additional equipment with a potential emission rate of no more than one (1) pound per hour for any pollutant for which a National or New Mexico Ambient Air Quality Standard has been set or one (1) pound per hour for any VOC;

(c) Permit revisions that incorporate a change in the permit solely involving the placement of permit conditions, including emissions limitations, on sources which existed on August 31, 1972 and which have been regularly operated since that time;

(d) Modifications that replace an emissions unit for which the allowable emissions limits have been established in the permit, provided that the new emissions unit:

(i) Is equivalent to the replaced emissions unit, and serves the same function within the facility and process;

(ii) Has the same or lower capacity and potential emission rates;

(iii) Has the same or higher control efficiency, and stack parameters which are at least as effective in the dispersion of air pollutants;

(iv) Would not result in an increase of the potential emission rate of any other equipment at the facility;

(v) Shall be subject to the same or lower allowable emissions limits under the permit, and to all other permit conditions which have applied to the replaced emissions unit;

(vi) Would not, when operated under applicable permit conditions, cause or contribute to a violation of any National or New Mexico Ambient Air Quality Standard; and

(vii) Would not, as determined by the Department, require additional permit conditions in order to ensure the enforceability of the permit, such as additional record keeping or reporting to show compliance;

(e) Permit revisions that make adjustments to the emissions limitations based on the result of the initial compliance test(s), provided that:

(i) The test is performed in accordance with permit conditions;

(ii) Such adjustment occurs within six (6) months of the compliance test;

(iii) No other such adjustment has occurred since the most recent permit issuance or reissuance;

(iv) Such adjustment does not: alter any other permit condition; trigger additional requirements under any other Part, including 20.2.74 NMAC (Prevention of Significant Deterioration); or result in allowable emissions which could contribute to a violation of any National or New Mexico Ambient Air Quality Standard;

(v) Such request does not increase the permitted allowable emissions of the unit(s) on which the initial compliance test(s) have been performed by more than ten (10) percent; and

(vi) Where the permit fee calculated under 20.2.75 NMAC (Construction Permit

Fees) would have been greater if it had been based on the potential emission rate as indicated by the compliance test, the balance of the permit fee is submitted as part of the technical permit revision application;

(f) Permit revisions that incorporate a change in the permit solely involving the addition of air pollution control equipment or the substitution of a different type of air pollution control equipment to existing equipment provided that such addition or substitution shall not result in an increase in the potential emission rate of more than one (1) pound per hour for any pollutant for which a National or New Mexico Ambient Air Quality Standard has been set, or one (1) pound per hour for total VOCs; or

(g) Permit revisions that incorporate terms and conditions in the permit, such as a cap on hours of operation, limitations on throughput of a specific product or products, or limitations on equipment capacity, for the purpose of reducing the potential emission rate of a unit or source.

(2) A request for a technical permit revision shall be accomplished by filing a certified written notification of the proposed revision with the Department on forms provided by the Department and shall include all information required by the Department to review the request. The certification shall be made as required under Paragraph 12 of Subsection A of 20.2.72.203 NMAC;

(3) The Department shall approve or deny the technical permit revision, or inform the applicant that the request must be submitted as a significant permit revision:

(a) Within thirty (30) days of receipt of the application; or

(b) If in response to significant public interest the Department holds a public meeting regarding the technical permit revision, within sixty (60) days of receipt of the application;

(4) The Department may deny an application for a technical permit revision or require that such application be submitted as a significant permit revision if:

(a) Such revision does not meet the criteria of this section;

(b) In the judgment of the Department the revision would require a decision on a significant or complex issue; or

(c) In the judgment of the Department the permittee has submitted multiple or subsequent applications for technical permit revisions under this Part that segment a larger revision or modification that would not be eligible for a technical permit revision;

(5) The technical permit revision shall become effective upon written approval from the Department;

(6) Technical permit revisions shall not be subject to public notification requirements under Paragraphs 1, 4 and 5 of Subsection B of 20.2.72.203 NMAC, and 20.2.72.206 NMAC. The Department shall attach the technical permit revision to the permit.

C. [RESERVED]

D. Significant Permit Revisions:

(1) A significant permit revision is required for any modification to a source, and for revisions to any term or condition of such permit, including but not limited to emissions limitation, control technology, operating conditions, and monitoring requirements; that:

(a) Do not meet the criteria under the provisions for administrative or technical permit revisions under Subsections A or B of 20.2.72.219 NMAC; or

(b) Meet the applicability criteria under 20.2.72.402 NMAC regarding toxic air pollutants;

(2) Applications for significant permit revisions shall meet all requirements of this Part for permits and shall be processed in accordance with the public notice, review, and hearing procedures set forth in this Part for such permits.

[20.2.72.219 NMAC - Rn, 20 NMAC 2.72.II.219, 02/02/01; A, 08/27/03]

20.2.72.220 GENERAL PERMITS:

A. Issuance of General Construction Permits:

(1) The Department may, after notice under Subsections A and B of 20.2.72.206 NMAC and a public hearing with opportunity for public participation under Subsection C of 20.2.72.206 NMAC issue one or more general construction permits, each covering numerous similar sources. Sources registered for coverage under a general permit shall be generally homogeneous in terms of operations, processes and emissions, subject to the same or substantially similar requirements, and not subject to case-by-case standards or requirements.

(2) Each general construction permit shall:

(a) Describe which sources may qualify to register under the general construction permit;

(b) Specify the contents of a complete application to register under the general construction permit. The Department may, in the general construction permit, provide for applications which deviate from the requirements under 20.2.72.203 NMAC, provided that such applications include:

i. All information necessary to determine qualification for, and to assure compliance with, the general construction permit; and

ii. Applicant's public notice requirements including, at a minimum, a notice: a) published once in the legal notices section of a newspaper in general circulation in the county or counties in which the property on which the facility is proposed to be constructed or operated is located; and b) posted at the proposed or existing facility entrance in a publicly accessible and conspicuous place on the property on which the facility is, or is proposed to be, located, until the general permit registration is granted or denied;

(c) Contain permit terms and conditions which apply to all sources registered under the general construction permit, and which include:

i. Sufficient terms and conditions to assure that all sources registered under and operating in accordance with the general construction permit will meet all applicable requirements under the federal Act, the New Mexico Air Quality Control Act and this Chapter (Air Quality), including 20.2.74 NMAC (Prevention of Significant Deterioration), 20.2.77 NMAC (New Source Performance Standards), 20.2.78 NMAC (Emission Standards for Hazardous Air Pollutants), 20.2.79 NMAC (Permits - Nonattainment Areas), and 20.2.82 NMAC (Maximum Achievable Control Technology Standards for Source Categories of Hazardous Air Pollutants), and will not cause or contribute to air contaminant levels in excess of any National or New Mexico Ambient Air Quality Standard; and

ii. Monitoring, record keeping and reporting requirements appropriate to the source and sufficient to ensure compliance with the general construction permit. At a minimum, the general permit shall specify where the records shall be maintained, how long the records shall be retained and that all records or reports shall be made available upon request by the Department;

iii. As appropriate, terms and conditions to address and report emissions occurring during upsets, startups and maintenance; and

(d) *Specify that any document, including any application form, report, compliance* certification and supporting data, submitted pursuant to this section (20.2.72.220 NMAC) shall contain a certification that meets the requirements of Paragraph 10 of Subsection A of 20.2.72.203 NMAC.

B. Revisions to a General Construction Permit:

(1) The Department may, after notice under Subsections A and B of 20.2.72.206 NMAC and a public hearing with opportunity for public participation under Subsection C of 20.2.72.206 NMAC, revise a general construction permit. Notice of the proposed revision shall also be sent to the owner or operator of all sources registered under the general construction permit.

(2) Revisions to a general construction permit shall include a reasonable transition schedule for existing registered sources to comply with the revised permit. The Department shall revise the general permit terms and conditions only to the extent necessary to ensure that the requirements of Sub-paragraph (c) of Paragraph 2 of Subsection A of 20.2.72.220 NMAC are met.

C. Registration under a General Construction Permit:

(1) The owner or operator of a source required to obtain a permit pursuant to this Part and which qualifies to register under a general construction permit shall either:

(a) Apply to the Department to register under the terms of the general construction permit; or

(b) Apply for a construction permit under 20.2.72.200 NMAC.

(2) Within thirty (30) days of receiving an application to register under a general construction permit, the Department shall review the application for completeness and shall grant or deny the registration. The Department shall not grant the registration until at least fifteen (15) days after the date the applicant's public notice was initiated. The Department shall notify the applicant of its determination by certified mail. The Department shall attach a copy of the general construction permit to registration approvals.

(3) The Department shall grant registration under a general permit to a source only if:

(a) The application is complete and meets the requirements of this section (20.2.72.220 NMAC); and

(b) The source meets the terms and conditions of the general permit.

(4) The Department may grant or deny an application to register under a general construction permit without repeating the public notice and participation procedures required under 20.2.72.206 NMAC.

(5) Administrative review under Sections 74-2-7.H through L NMSA 1978 shall be available for a determination made by the Department of whether or not a source qualifies to register for coverage under a general construction permit. However, administrative review of a registration for coverage under a general construction permit shall not extend to administrative review of the general permit itself. Administrative review of the general construction permit shall be available under Sections 74-2-7.H through L NMSA 1978 only upon issuance or revision of the general permit as a permitting action.

(6) Sources shall be subject to enforcement action for construction without a permit if:

(a) Construction of a source is commenced prior to the receipt of the Department's written approval of registration under a general construction permit; or

(b) It is determined after construction commences that a source does not qualify for coverage under the general construction permit.

(7) A general permit registration may be canceled, consistent with the provisions of 20.2.72.211 NMAC, for any source which ceases operation for five years or more, or permanently, and for any source for which the construction or modification is not commenced within two years from the date of issuance or, if during the construction or modification, work is suspended for a total of one year. The owner or operator shall notify the Department of the anticipated and actual startup of a source, consistent with the provisions of 20.2.72.212 NMAC.

D. Modifications to Sources Registered Under a General Construction Permit: Each general construction permit shall provide that, prior to modification of a source which is registered under a general construction permit, the owner or operator shall:

(1) For those modifications for which the facility will continue to meet the conditions of the general construction permit after the modification, notify the Department in writing of such modification; and

(2) For those modifications for which the source will not continue to meet the conditions of the general construction permit after such modification, obtain a construction permit from the Department under this Part prior to the modification.

[20.2.72.220 NMAC - Rn & A, 20 NMAC 2.72.II.220, 2/2/01]

20.2.72.221 ACCELERATED REVIEW:

A. Qualified Outside Firms:

(1) The Department shall request proposals from persons interested in providing assistance as a qualified outside firm in the accelerated review of construction permit applications under this Part.

(2) The Department shall evaluate the proposal submitted by the person. To be eligible to contract with the Department as a qualified outside firm a person must:

(a) Be legally qualified to contract with the Department; and

(b) Be qualified to assist the Department in review of permit applications, as determined by the Department in the Department's sole discretion.

(3) Persons who are selected as qualified outside firms shall be under contract with the Department for accelerated review of construction permit applications under this section.

B. Requests for Accelerated Review:

(1) At the sole discretion of the applicant, a construction permit applicant under this Part may request accelerated permit review of the application by a qualified outside firm. Applications for accelerated review shall be preceded by a pre-application meeting between the applicant and the Department. Requests for accelerated review shall not be granted unless there is at least one qualified outside firm under contract with the Department pursuant to Paragraph 3 of Subsection A of 20.2.72.221 NMAC. If there are no firms under contract to provide accelerated review, the Department shall review the application in accordance with 20.2.72.207 NMAC.

(2) Such request for accelerated permit review shall be submitted with the construction permit application along with a corporate check or money order for the amount of the accelerated review filing fee as specified in 20.2.75 NMAC. The Department shall notify the applicant of the names and addresses of the qualified outside firms. The applicant shall deliver a copy of the application, by mail or hand delivery, to each qualified outside firm identified by the Department, unless the applicant is aware of a conflict of interest.

(3) Participation in the accelerated permit review process shall not relieve the applicant of any responsibilities specified in this chapter.

(4) Applicants who have opted for accelerated review under this section shall be subject to supplementary fees pursuant to 20.2.75 NMAC which shall be assessed in addition to all other applicable fees levied under 20.2.75 NMAC.

(5) Qualified outside firms under contract which are interested in performing the accelerated review on a specific application shall submit to the Department:

(a) A statement of interest;

(b) A statement of qualifications for that specific application;

(c) An estimate of the cost and schedule for the review; and

(d) A notarized affidavit attesting that no conflict of interest exists on the specific permit application.

(6) If no qualified outside firm submits the four items required by Paragraph 5 of Subsection B of 20.2.72.221 NMAC, the Department shall apply the accelerated review filing fee to the permit fee in accordance with 20.2.75 NMAC and review the application without the assistance of a qualified outside firm and in accordance with 20.2.72.207 NMAC.

(7) The Department shall review the submittals and determine, in the Department's sole discretion, which firms qualify for any specific application.

(8) Prior to determining any application administratively complete for which accelerated review has been requested as allowed under 20.2.72.203 NMAC, the Department shall provide the applicant a written summary of the qualified submittals showing the costs to the applicant of the accelerated review and the anticipated schedule for application review, permit development and permit issuance.

(9) Applicant's Responsibilities for Response to Submittal Summary:

(a) Within five (5) working days of receipt of the Department's bid summary the applicant shall either: (i) submit to the Department a written recommendation to accept one of the accelerated review bids, or a prioritized list of more than one of the accelerated review bids, including a brief justification for the recommendation(s) along with a corporate check or money order payable to the Department for the amount of the accelerated review bid and a notarized affidavit attesting that no conflict of interest exists on the specific permit application; or (ii) submit to the Department a written withdrawal of the request for accelerated review.

(b) The request for accelerated review is deemed withdrawn if the applicant fails to submit a written recommendation or withdrawal within five (5) working days of receipt of the Department's bid summary unless the Department has granted an extension.

(10) Department's Selection of Qualified Outside Firm

(a) If the request for accelerated review is withdrawn, the Department shall retain the accelerated review filing fee in accordance with 20.2.75 NMAC and shall review the application without the assistance of a qualified outside firm and in accordance with 20.2.72.207 NMAC.

(b) If the applicant recommends a qualified submittal, the Department shall determine whether to accept the recommended submittal. If the Department accepts the recommended submittal it shall instruct the qualified outside firm to begin review of the application. If the Department rejects the recommended submittal, it shall inform the applicant and allow the applicant to recommend an alternate submittal pursuant to Paragraph 9 of Subsection B of 20.2.72.221 NMAC or, if there are no other qualified submittals, the Department shall retain the accelerated review filing fee in accordance with 20.2.75 NMAC and review the application without the assistance of a qualified outside firm and in accordance with 20.2.72.207 NMAC.

C. Disclosure of Conflicts During Accelerated Review:

(1) The applicant and the qualified outside firm have a continuing obligation to investigate potential conflicts of interest and to immediately disclose, in writing, any conflict of interest to the Department. If a conflict of interest was not disclosed pursuant to Subparagraph d of Paragraph 5 of 20.2.72.221 NMAC or Subparagraph a of Paragraph 9 of Subsection B of 20.2.72.221 NMAC, and is later disclosed or discovered, the Department may:

(a) Deny the application pursuant to 20.2.72.208 NMAC;

(b) Terminate accelerated review and review the application pursuant to 20.2.72.207 NMAC; or

(c) Allow accelerated review to continue after elimination of the conflict.

(2) In choosing between these options the Department shall consider whether the conflict of interest was disclosed or discovered, the timing of the disclosure or discovery, diligence in investigating potential conflicts of interest, any indication of intentional or willful failure to disclose, significance of the conflict of interest, and ability to eliminate the conflict of interest in a timely manner.

D. Issuance of a Permit After Accelerated Review:

(1) Upon completion of the review, the qualified outside firm shall provide the Department with all documentation, including but not limited to all communications, notes, and drafts, pertaining to the permit application. At any time during the review, the qualified outside firm shall provide all documentation pertaining to a specific application to the Department upon request. Such documentation shall be subject to the Inspection of Public Records Act, Chapter 14, Article 2 NMSA 1978, and the Confidential Information Section of the Air Quality Control Act, Section 74-2-11 NMSA 1978.

(2) The Department shall review the analysis prepared by the qualified outside firm and shall issue a permit or deny the permit application in accordance with this Part. The qualified outside firm's analysis is not binding on the Department. The Department retains final authority to accept or reject the qualified outside firm's analysis regarding the permit application.

(3) The Department shall not issue the permit until both the accelerated review processing fee and any fees due pursuant to 20.2.75 NMAC have been paid.

[20.2.72.221 NMAC - N, 3/30/01]

20.2.72.222- 20.2.72.299 [RESERVED]

20.2.72.300 DEFINITIONS:

In addition to the definitions in 20.2.72.7 NMAC, the following definitions apply to 20.2.72.300 NMAC - 20.2.72.399 NMAC:

A. "Compressor station" means a facility whose primary function is the extraction of crude oil, natural gas, or water from the earth with compressors, or movement of any fluid, including crude oil or natural gas, or products refined from these substances through pipelines or the injection of natural gas or CO2 back into the earth using compressors. A compressor station may include engines to generate power in conjunction with the other functions of extraction, injection or transmission and may contain emergency flares. A compressor station may have auxiliary equipment which emits small quantities of regulated air contaminants, including but not limited to, separators, de-hydration units, heaters, treaters and storage tanks, provided the equipment is located within the same property boundaries as the compressor engine.

B. "Good engineering practice stack height" means HsubGEP = H + 1.5L, where H equals the height of any building or obstruction within 5L of the stack, and L equals the lesser of the height or maximum projected width of the building or obstruction.

C. "Impact area" means the circular area with a radius extending from the source to the most distant point where the total potential emissions from the facility will cause a significant ambient impact (i.e., equal or exceed the applicable significant ambient impact level in 20.2.72.500 NMAC.

D. "Maximum projected width" means the largest crosswind building or obstruction dimension.

E. "Potential to emit" or **"potential emissions"** means the maximum capacity of a stationary source to emit a regulated air contaminant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitations or the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source.

F. **"Secondary emissions"** means emissions of an air contaminant which occur as a result of the construction or operation of a stationary source or modification, but do not come from the stationary source or modification itself. Secondary emissions must be specific, well defined, quantifiable, and impact the same general areas as the stationary source or modification which causes the secondary emissions. Secondary emissions include emissions from any offsite support facility which would not be constructed or increase its emissions except as a result of the construction or operation of the stationary source or modification. Secondary emissions do not include any emissions which come directly from a mobile source, such as emissions from the tailpipe of a motor vehicle, from a train, or from a vessel.

G. **"SUM"** means the sum of the potential emissions for oxides of nitrogen from all adjacent sources.

H. **"SUM15"** means the sum of the potential emissions for oxides of nitrogen from all adjacent sources within 15 km of the NO2 impact area.

I. **"SUM25"** means the sum of the potential emissions for oxides of nitrogen from all adjacent sources within 25 km of the NO2 impact area.

J. **"Sweet natural gas"** means natural gas containing no more than 0.25 grains of hydrogen sulfide per 100 standard cubic feet of gas.

[20.2.72.300 NMAC - Rn & A, 20 NMAC 2.72.III.300, 2/2/01]

20.2.72.301 APPLICABILITY:

A. Any owner or operator intending to construct or modify a source which requires a permit under the provisions of 20.2.72.200 NMAC may elect to obtain a permit under 20.2.72.300 NMAC - 20.2.72.399 NMAC if the source category is listed in 20.2.72.501 NMAC.

B. 20.2.72.300 NMAC - 20.2.72.399 NMAC shall not apply to:

(1) Any "major stationary source" as defined in 20.2.74 NMAC;

(2) Any facility, either before or after construction or modification, with a total potential to emit of any regulated air contaminant greater than 200 tons per year (tpy);

(3) Any source subject to the requirements of 20.2.78 NMAC or 20.2.72.400 NMAC - 20.2.72.499 NMAC;

(4) Any reciprocating internal combustion (IC) engines and/or turbines located at petroleum refineries, chemical manufacturing plants, bulk gasoline terminals, natural gas processing plants, or at any facility containing sources in addition to IC engines and/or turbines for which an air quality permit is required through state or federal air quality regulations;

(5) Any source which emits or proposes to emit those contaminants for which the impact area from the facility intersects an area, or for which the area itself is: 1) designated nonattainment for federal ambient air quality standards; or 2) nonattainment for federal PSD increments or state ambient air quality standards according to ambient data or air quality modeling; or 3) shown by air quality data or dispersion or other air quality modeling that air contaminants have consumed more than 80% of state or federal ambient air quality standards or PSD increments for those areas where the baseline has been triggered for the specific PSD increments;

(6) Any source with the nearest property boundary located less than:

(a) 1 kilometer (km) from a school, residence, office building, or occupied structure. Buildings and structures within the immediate industrial complex of the source are not included.

(b) 3 km from the property boundary of any state park, Class II wilderness area, Class II national wildlife refuge, national historic park, state recreation area, or community with a population of more than twenty-thousand people.

(c) 10 km from the boundary of any community with a population of more than forty-thousand people, or

(d) 30 km from the boundary of any Class I area;

(7) Any source located in Bernalillo County or within 15 km of the Bernalillo County line.

C. The following sections and subsections of 20.2.72.200 NMAC - 20.2.72.299 NMAC apply to permit applications submitted pursuant to 20.2.72.300 NMAC - 20.2.72.399 NMAC: Subsections A, B and E through H of 20.2.72.200 NMAC, 20.2.72.202 NMAC, 20.2.72.204 NMAC, 20.2.72.205 NMAC, Subsection C of 20.2.72.206 NMAC, Subsections D through G of 20.2.72.207 NMAC, 20.2.72.208 NMAC, 20.2.72.209 NMAC, 20.2.72.210 NMAC, 20.2.72.211 NMAC, 20.2.72.212 NMAC, 20.2.72.214 NMAC and 20.2.72.215 NMAC. The remainder of 20.2.72.200 NMAC - 20.2.72.299 NMAC does not apply to applications submitted pursuant to 20.2.72.300 NMAC - 20.2.72.399 NMAC.

D. Any source, including compressor stations, consisting of IC engines and/or turbines must comply with one of the following three criteria, Paragraph 1, 2, or 3 of Subsection D of 20.2.72.301 NMAC, in order to qualify for source class permit streamlining under 20.2.72.300 NMAC - 20.2.72.399 NMAC (In demonstrating compliance with Subsection D of 20.2.72.301 NMAC, the Department shall give no credit for modeled reductions in ambient air concentrations due to so much of a source's stack which exceeds good engineering stack height, or fifty (50) feet in situations where there are not obstructions or buildings associated with the source):

(1) The total potential to emit of each regulated contaminant from all sources at the facility shall be less than 40 tpy. The potential to emit for nitrogen dioxide shall be based on total oxides of nitrogen; or

(2) The total potential to emit of each regulated contaminant from all emission sources at the facility shall be less than 100 tons per year (tpy) and the impact on ambient air from all sources at the facility shall be less than the ambient significance levels in 20.2.72.500 NMAC, Table 1. The potential to emit for nitrogen dioxide shall be based on total oxides of nitrogen expressed as nitrogen dioxide; or

(3) The maximum modeled ambient impact from the total potential emissions at the facility shall be less than 50 percent of each applicable PSD increment, for those areas where the baseline has been triggered for the specific PSD increments, and state and federal ambient air quality standards; and

(a) There shall be no adjacent sources emitting the same regulated air contaminant(s) as the source within 2.5 km of the modeled nitrogen dioxide (NO2) impact area; and

(b) The "sum of the potential emissions for oxides of nitrogen from all adjacent sources" (SUM) within 15 km of the NO2 impact area (SUM15) shall be less than 740 tpy; and

(c) The SUM25 within 25 km from the NO2 impact area shall be less than 1540 tpy.

(4) Modifications to the auxiliary emission generating equipment at a facility qualifying and electing source class permit streamlining may commence without obtaining a permit for such modification as long as the total potential to emit of all auxiliary equipment remains at or below 1.0 lb/hr for any one regulated air contaminant and as long as the total potential to emit of each regulated air contaminant from the compressor station meets the requirements of Paragraphs 1 or 2 of Subsection D of 20.2.72.301 NMAC or previously qualified under Paragraph 3 of Subsection D of 20.2.72.301 NMAC.. The applicant shall provide, in writing, the nature of all changes to the Department no later than 15 days prior to the expected change.

[20.2.72.301 NMAC - Rn & A, 20 NMAC 2.72.III.301, 2/2/01]

[Annotated Note: Section 20.2.72.202 - Permit Revisions, which is referenced in Subsection C of this section, was renumbered to Section 20.2.72.219 NMAC, effective 1/7/1998]

20.2.72.302 CONTENTS OF APPLICATION:

A. Any person seeking a permit under 20.2.72.300 NMAC - 20.2.72.399 NMAC shall do so by filing a written application with the Department. For those applications not qualifying under Subsection A of 20.2.72.303 NMAC, the applicant shall also:

(1) Provide by certified mail a complete copy of the application and public notice to the Department's field or district office nearest the source; and

(2) Provide by certified mail a copy of the public notice to the appropriate federal land manager if the source will locate within 50 km of the boundary of a Class I area.

B. The items of this section, if requested on the applicable application form, are required before the Department may deem an application administratively complete. The applicant shall submit the number of copies of the permit application specified in the applicable application form. All applications shall be filed on the forms furnished by the Department and shall include:

(1) The applicant's name and address, the person to contact regarding the application, and the name and address of the new source or modification;

(2) A description of the new facility or modification including all operations effecting air emissions;

(3) The anticipated operating schedule;

(4) A topographical map, at least as detailed as a 7.5 minute United States Geological Survey Topographic Quadrangle, showing the exact location and geographical coordinates of the stationary source;

(5) The Universal Transverse Mercator (UTM) horizontal and vertical coordinates for the facility;

(6) A plot plan showing the location of emission units with respect to the plant's property boundaries and the dimensions of any buildings, terrain, or obstructions which may cause emissions to be downwashed;

(7) A detailed description of any air pollution control device or method to be utilized, including the basis for the estimated control efficiency;

(8) The stack and exhaust gas parameters for all emission points, including calculations and manufacturer's or supplier's data which documents the emission rates and exhaust gas parameters;

(9) A comprehensive regulatory compliance review, including all pertinent data and calculations, for each applicable new source performance standard, such as 40 CFR 60, Subpart GG - Standards of Performance for Stationary Gas Turbines;

(10) Documentation of the manufacturer's or supplier's recommended maintenance schedules and procedures for all air pollution control equipment;

(11) A compliance demonstration based on US EPA approved modeling or analysis, including all pertinent calculations and computations, for all applicable requirements of 20.2.72.300 NMAC - 20.2.72.399 NMAC for any facility electing to obtain a permit under 20.2.72.300 NMAC - 20.2.72.399 NMAC;

(12) Documentary proof that the requirements of Paragraphs 1 and 2 of Subsection A of 20.2.72.302 NMAC have been satisfied;

(13) The notarized signature under oath or affirmation by the operator, the owner, or an authorized representative, certifying to the best of his or her knowledge the truth of all information submitted;

(14) Payment of any fees which are specified in 20.2.75 NMAC (Construction Permit Fees) as payable at the time the application is submitted; and

(15) Any other specifically identified relevant information as the Department may reasonably require.

[20.2.72.302 NMAC - Rn & A, 20 NMAC 2.72.III.302, 2/2/01]

20.2.72.303 PUBLIC NOTICE AND PARTICIPATION:

A. Applications qualifying under the following paragraphs of 20.2.72.300 NMAC - 20.2.72.399 NMAC are not subject to Subsection B of 20.2.72.303 NMAC and Paragraph 2 of Subsection C of 20.2.72.303 NMAC: Paragraphs 1 and 2 of Subsection D of 20.2.72.301 NMAC.

B. The applicant shall:

(1) Publish notice once in a newspaper of general circulation in the area closest to the location of the source. This notice shall appear in either the classified or legal advertisements section of the newspaper. Notice shall be published in accordance with Department guidance documents and must include:

(a) The applicant's name and address;

(b) The address and phone number of the Department's Air Quality Bureau in Santa Fe, and the address of the field or district office where a copy of the application will be sent as required in Subsection A of 20.2.72.302 NMAC;

(c) The location and a brief description of the source;

(d) A summary of estimated emissions and ambient impact for each regulated contaminant for the entire facility;

(e) Where required in 20.2.72.300 NMAC - 20.2.72.399 NMAC, the applicant's public notice shall contain the following statement: "Any comments submitted on this permit application should address the relevant requirements of state and federal air quality regulations and the Federal Clean Air Act and the state Air Quality Control Act. The comments shall be submitted to the Department's Air Quality Bureau in Santa Fe within thirty (30) days following the date of publication";

(f) Any other information required by the Department; and

(2) Post the notice at the proposed or existing facility entrance on the property on which the facility is, or is proposed to be located prior to submittal of the application and remaining posted until the Department takes final action on the permit.

C. The Department shall:

(1) Make available for public inspection the permit application. Copies of any permit application, except those portions of which may be determined as confidential in accordance with 20.2.1 NMAC (General Provisions), will be supplied upon written request and payment of reasonable costs.

(2) Allow all interested persons thirty (30) days from the date of publication of the applicant's public notice in a newspaper of general circulation, to submit written comments or evidence on the application.

[20.2.72.303 NMAC - Rn & A, 20 NMAC 2.72.III.303, 2/2/01]

20.2.72.304 PERMIT DECISIONS:

A. The Department shall within thirty (30) days after its receipt of an application for a permit or permit revision review such application and determine whether it is administratively complete.

(1) If the application is deemed administratively complete, a certified letter to that effect shall be sent to the applicant.

(2) If the application is deemed administratively incomplete, a certified letter shall be sent to the applicant stating what additional information or points of clarification are necessary to deem the application administratively complete. Upon receipt of such information, the Department shall promptly review such information and determine whether the application is administratively complete.

(3) If the application is deemed administratively complete but no permit is required, a certified letter shall be sent to the applicant informing the applicant of the determination.

B. The Department shall either grant, grant subject to conditions, or deny the permit or permit revision as soon as practicable after the Department deems the application administratively complete but not to exceed the times specified below:

(1) For applications qualifying under the Paragraphs 1 and 2 of Subsection D of 20.2.72.301 NMAC, within thirty (30) days;

(2) For all other applications, within sixty (60) days, or ninety (90) days if there is a hearing under 20.2.72.206 NMAC.

[20.2.72.304 NMAC - Rn & A, 20 NMAC 2.72.III.304, 2/2/01]

20.2.72.305 GENERAL REQUIREMENTS:

All sources permitted pursuant to 20.2.72.300 NMAC - 20.2.72.399 NMAC shall operate in compliance with the following conditions:

A. A copy of the most recent permit issued by the Department shall be made available to Department personnel for inspection upon request. If the permit is not kept at the plant location, a notice at the plant site shall be located in a conspicuous place stating the facility name and ownership, air quality permit number, and the address and phone number of the Department in Santa Fe;

B. The source shall operate in compliance with all applicable state and federal regulations, including federal new source performance standards incorporated by 20.2.77 NMAC and permit conditions;

C. The owner or operator of the source shall be required to conduct such performance tests as specified by the Department to determine compliance with emission limitations or technology requirements as specified in an applicable regulation or permit condition. Specific schedules and requirements will be listed in 20.2.72.306 NMAC for each source class and/or in the permit. Performance test requirements may be reimposed on a source as necessary if inspections of the source or other information available to the Department, indicate noncompliance, or the previous test showed noncompliance or was technically unsatisfactory. In such cases, the Department may reimpose such tests as frequently as necessary until compliance is achieved and testing is performed in a manner technically satisfactory to the Department. The owner or operator shall:

(1) Arrange a pretest meeting with the Department at least two weeks prior to the anticipated test date for all tests;

(2) Notify the Department at least thirty (30) days prior to the date and time of performance testing, and provide the Department an opportunity to have an observer present during testing;

(3) Conduct performance tests in accordance with methods and procedures specified by the Department. Whenever the requirements of 40 CFR 60 apply, test methods must be utilized as specified in those regulations;

(4) Submit a written report to the Department of the results of the test within thirty (30) days from the test date; and

D. The owner or operator using a catalytic converter to meet the requirements of 20.2.72.300 NMAC - 20.2.72.399 NMAC shall satisfactorily test the reduction efficiency across the

catalyst bed and report the results of the test to the Department according to the permit conditions, within ninety (90) days following initial start-up and on a quarterly basis thereafter, unless an alternative testing schedule is specified by the Department. The tests shall be conducted in accordance with the requirements of Subsection C of 20.2.72.305 NMAC and as required in the permit, except that the requirements of Paragraphs 1 and 2 of Subsection C of 20.2.72.305 NMAC shall be waived unless the Department specifically requests a pretest meeting or notification of the next test date.
[20.2.72.305 NMAC - Rn & A, 20 NMAC 2.72.III.305, 2/2/01]

20.2.72.306 SOURCE CLASS REQUIREMENTS:

A. In addition to the general conditions of 20.2.72.305 NMAC, each permitted source listed in 20.2.72.501 NMAC (Table 2) shall also comply with the applicable source class requirements below:

(1) Requirements for source class category 1 - reciprocating internal combustion (IC) engines:

(a) Gas fuel shall be produced natural gas, sweet natural gas, liquid petroleum gas, or fuel gas. No gas fuel shall contain more than 0.1 grain of total sulfur per dry standard cubic foot. Liquid fuel shall be first run refinery grade diesel or No. 2 fuel oil that is not a blend containing waste oils or solvents and contains less than 0.3% by weight sulfur;

(b) Within ninety (90) days after initial start-up of the source, the owner or operator shall conduct NOx and carbon monoxide (CO) performance tests on one or more engines (turbines) at the facility to ensure the facility is in compliance with 20.2.72.300 NMAC - 20.2.72.399 NMAC and permit requirements, including emission limits and any applicable pollution control device reduction efficiency requirements for NOx. The Department shall specifically identify in the permit each engine or turbine subject to initial performance testing requirements. Tests shall be conducted in accordance with the requirements of Subsection C of 20.2.72.305 NMAC;

(c) Any engine which operates with a non-selective catalytic converter shall comply with the following requirements:

i. Any spark ignited gas-fired or any compression ignited dual fuel-fired engine shall be equipped and operated with an automatic air-fuel ratio (AFR) controller which maintains AFR in the range required to minimize NOx emissions, as recommended by the manufacturer; and

ii. The owner or operator shall make and maintain records to demonstrate that the manufacturer's or supplier's recommended maintenance is performed, including replacement of the oxygen sensor as necessary for oxygen-based AFR controllers, and cleaning, regeneration, and/or replacement of catalyst(s) as necessary to maintain at least the NOx reduction efficiencies across the catalyst bed that are specified in the permit.

B. Requirements for source class category 2 - turbines: The source must comply with Paragraphs 1 and 2 of Subsection A of 20.2.72.306 NMAC.
[20.2.72.306 NMAC - Rn & A, 20 NMAC 2.72.III.306, 2/2/01]

20.2.72.307- 20.2.72.399 [RESERVED]

20.2.72.400 PREAMBLE:

The Board is concerned about the increasingly common presence of toxic air pollutants in the ambient air. The Board believes that the best approach to regulating sources of toxic air pollutants over the long term is to set ambient standards for each pollutant of concern.

However, because of financial constraints, the unavailability of sufficient information to establish such ambient standards, the time necessary to establish such standards for the contaminants identified as toxic air pollutants and because the Board wishes to implement a toxic air pollutant permitting program as soon as possible, the Board has adopted a source-by-source permit-based approach for the present. Under this permit-based approach, the Board has given limited authority to the Department to use factors of the OELs (occupational exposure limits) in evaluating permit applications. The Board recognizes that the use of OELs, or factors of them, as ambient air standards would be inappropriate; therefore, the Board has authorized their use for screening purposes only. This authorization is not intended to represent, and should not be interpreted as, a finding by the Board that these factors are suitable for determining safe or unsafe ambient air concentrations. Various respected groups, such as the American Conference of Governmental Industrial Hygienists (ACGIH), may develop ambient air exposure guidelines in the future. Development of ambient air guidelines by groups such as this could be the basis for developing toxic air pollutant ambient air standards. The Board also notes that the Department currently is developing an emissions inventory of toxic air pollutants. An emissions inventory may identify toxic air pollutants that are of particular concern in New Mexico. The Board believes that efforts like these may facilitate the development of toxic air pollutant ambient air standards. For these reasons, the Board requests the Department to prepare and present a report to the Board within five years of the effective date of the toxic air pollutant permitting requirements. The report shall review and evaluate the implementation of the toxic air pollutant permitting program, summarize the results of the toxic air pollutant inventory gathered pursuant to AQCR 752, and review scientific and technical progress made in the area of toxic air pollutants that might facilitate the development of toxic air pollutant ambient air standards. The Board shall schedule a discussion of this report at a regular monthly meeting within three months of the publication of this report.
[20.2.72.400 NMAC - Rn & A, 20 NMAC 2.72.IV.400, 2/2/01]

20.2.72.401 DEFINITIONS:
In addition to the definitions in 20.2.72.7 NMAC, the following definitions apply to 20.2.72.400 NMAC - 20.2.72.499 NMAC:

A. **"Best available control technology"** means an emission limitation based on the maximum degree of reduction in emissions of each contaminant subject to this Part which the Secretary (or the Board), on a case-by-case basis, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts resulting from the use of such technology, determines is achievable for the source, through application of measures, processes, methods, systems, or techniques including, but not limited to, measures which:

(1) Reduce the volume of such pollutants through process changes, substitutions of materials, or other modifications, or

(2) Enclose systems or processes to eliminate emissions, or

(3) Collect, capture or treat such pollutants when released from a process, stack, storage, or fugitive emission point.

B. **"Existing source"** means any source, the construction or modification of which was commenced on or before December 31, 1988.

C. **"Fixed capital costs"** means that capital needed to provide all the depreciable components.

D. **"New source"** means any source, the construction of which is commenced after December 31, 1988. The term does not include any new source which is integrally related with and integrally connected to the process of an existing source. The term includes the reconstruction of an existing source.

E. **"Occupational Exposure Limit"** or **"OEL"** means the eight-hour time weighted average concentration specified for workroom air in "Threshold Limit Values and Biological Exposure Indices for 1986-1987" as adopted by the American Conference of Governmental Industrial Hygienists, or for compounds not assigned an OEL in that document, the minimum detection limit specified in the National Institute for Occupational Safety and Health "Manual of Analytical Methods", Third Edition.

F. **"Oil and gas production facilities"** means facilities for the exploration, development, production, treatment, separation, storage, transport, and sale of unrefined hydrocarbons, natural gas liquids, and CO2 (e.g., major SIC group 13, oil and gas extraction, SIC industry group no. 4612, crude, petroleum, pipeline and SIC industry no. 4922, natural gas transmission). Natural gas processing plants and refineries are not included for purposes of this definition.

G. **"Reconstruction"** means a modification which results in the replacement of the components or addition of integrally related equipment to an existing source to such an extent that the fixed capital cost of the new components or equipment exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility.

H. **"Toxic air pollutant"** means any air contaminant in 20.2.72.502 NMAC.

[20.2.72.401 NMAC - Rn & A, 20 NMAC 2.72.IV.401, 2/2/01]

20.2.72.402 APPLICABILITY:

A. All the requirements of 20.2.72.400 NMAC - 20.2.72.499 NMAC for toxic air pollutants shall supplement other provisions of this Part (20.2.72 NMAC).

B. A permit must be obtained from the Department by any person prior to the construction or modification of a new source which has total potential emissions of a toxic air pollutant into the ambient air that exceed the emission level in pounds per hour specified in 20.2.72.502 NMAC, and one or more of the following conditions are met:

(1) The toxic air pollutant is listed under applicable primary and secondary SIC codes appropriate for the source in the US EPA SIC/Pollutant Index (Appendix C of EPA-450/4-86-010); or

(2) The toxic air pollutant is known by the owner or operator to be emitted into the ambient air because of:

(a) Information from material safety data sheets and hazard labelling required under the OSHA Hazard Communications Standard 29 CFR 1910.1200, or

(b) Information from reports required under the Federal Emergency Planning and Community Right-to-Know Act of 1986, P.L. 99-499, Title III, Sections 300-330, or

(c) Other information reasonably available to the owner or operator based on the source's obligations under other regulatory programs; or

(3) The toxic air pollutant is identified by the Department on or before the date the application is determined to be complete, as likely to be emitted from a source. The Department shall also provide the owner or operator a reasonable basis to support the belief that the source will emit such toxic air pollutant.

C. The following classes of sources are exempt from the permitting requirements for toxic air pollutants:

(1) Gasoline Service Stations - SIC No. 5441
(2) Automotive Repair Shops - SIC No. 753
(3) Laundry, Cleaning, and Garment Services - SIC No. 721
(4) Domestic Woodstoves and Fireplaces
(5) Oil and Gas Production Facilities
(6) Agricultural Production - Crops, SIC No. 01
(7) Agricultural Production - Livestock, SIC No. 02
(8) Agricultural Services - SIC No. 07

(9) Containers, such as tanks, barrels, drums, cans and buckets, unless equipped with a vent that emits or may emit any toxic air pollutant, which are used in connection with the operation, maintenance or repair of a stationary source.

(10) Non-process fugitive emissions of toxic air pollutants from stationary sources, such as construction sites, unpaved roads, coal piles, tailings piles, waste piles, and fuel and ash handling operations.

D. An exemption or exclusion from the permitting requirements for toxic air pollutants does not relieve a source from any other requirements in this Part (20.2.72 NMAC).

[20.2.72.402 NMAC - Rn & A, 20 NMAC 2.72.IV.402, 2/2/01]

20.2.72.403 CONTENTS OF APPLICATION:

A. For the Department to deem administratively complete a permit application for the emission of a toxic air pollutant, the application shall contain, in addition to the requirements of 20.2.72.203 NMAC, the following items:

(1) Identification of all toxic air pollutants that may be emitted in excess of the screening level (specified in pounds per hour) in 20.2.72.502 NMAC;

(2) Air quality modeling, in accordance with methods approved by the US EPA or the Department, that estimates ambient concentrations that would be caused by the proposed emissions. The modeling for the toxic air pollutants will include available emissions supplied by the Department from registration and permitting information from all registered or permitted sources in the area of the source being permitted.

B. If the modeling shows that the eight-hour average ambient concentration of the toxic air pollutant exceeds one-one hundredth of the OEL and the toxic air pollutant is not identified as a known or suspected human carcinogen in 20.2.72.502 NMAC, Table B, the permit application shall also include, as a requirement for administrative completeness, a health assessment for the toxic air pollutant under consideration. The assessment shall include consideration of the following:

(1) Source to potential receptor data and modeling;
(2) Relevant environmental pathway and effects data;
(3) Available health effects data such as:
  (a) Functional diseases;
  (b) Mutagenicity data as an index of genotoxic effects including heritable diseases;
  (c) Reproductive effects data;
  (d) Other diseases; and

(4) An integrated assessment of the human health effects for projected exposures from the applicant's facility. The assessment should use existing relevant data obtained from epidemiological studies, controlled human exposure studies, laboratory animal studies, and studies using tissues and cells.

C. If the toxic air pollutant is identified as a known or suspected human carcinogen in 20.2.72.502 NMAC and air quality modeling shows that the eight-hour average concentration of the toxic air pollutant exceeds one one-hundredth of the OEL or the minimum detection level in 20.2.72.502 NMAC, the permit application shall include, as a requirement for administrative completeness, information necessary to demonstrate the source will install the best available control technology to control that pollutant.
[20.2.72.403 NMAC - Rn & A, 20 NMAC 2.72.IV.403, 2/2/01]

20.2.72.404 PUBLIC NOTICE AND PARTICIPATION:
In addition to the requirements of 20.2.72.206 NMAC:

A. The Department shall meet with the applicant during the permit application process, prior to deeming the application administratively complete, to discuss the need for additional data and information not initially submitted by the applicant; and

B. The Department shall promptly advise the applicant of all medical or other scientific evidence the Department uses to evaluate the health effects of the toxic air pollutant emissions and make available to the applicant in a timely manner all information, including all previous decisions on the toxic air pollutant in question.
[20.2.72.404 NMAC - Rn & A, 20 NMAC 2.72.IV.404, 2/2/01]

20.2.72.405 PERMIT DECISIONS:
In making its decisions, the Department shall consider emissions after control.

A. Ambient concentrations not exceeding one one-hundredth of the OEL or the minimum detection level for compounds without an OEL: If the Department finds that the eight-hour average concentration of the toxic air pollutant in the ambient air does not exceed one one-hundredth of the OEL, or for compounds without an OEL, the minimum detection levels as shown in 20.2.72.502 NMAC, the Department shall grant the permit. The administrative screening level of one one-hundredth the OEL and the OEL shall not be a basis for denying a permit and shall not constitute an ambient air quality standard.

B. Ambient concentrations exceeding one one-hundredth of the OEL or the minimum detection level for compounds without an OEL for substances identified as known or suspected human carcinogens in 20.2.72.502 NMAC: If the toxic air pollutant being considered is identified as a known or suspected carcinogen in 20.2.72.502 NMAC, Table B, and the Department finds the eight-hour concentration of the toxic air pollutant in the ambient air exceeds one one-hundredth of the OEL, or for compounds without an OEL, the minimum detection level, the Department shall grant the permit if the applicant implements the best available control technology to control that pollutant.

C. Ambient concentrations exceeding one one-hundredth of the OEL for substances not identified as carcinogens in 20.2.72.502 NMAC:

(1) If the applicant has been required to prepare a health assessment under Subsection B of 20.2.72.403 NMAC, the Department shall prepare a Summary Review Statement (SRS) which indicates the Department's opinion of the adequacy of the applicant's health assessment. The SRS will include a summary recommendation on whether the issuance of a permit will or will not with reasonable probability injure human health.

(2) If the applicant does not agree with the recommendation contained in the SRS, the applicant's assessment and the SRS will be provided to the Air Toxics Scientific Advisory Committee (ATSAC). The ATSAC will be composed of five members appointed by the Secretary. They will include physicians, toxicologists, industrial hygienists, or others knowledgeable of the potential health and environmental effects of air pollution. The committee will include at least one member nominated by the applicant. The ATSAC will review the applicant's assessment and the SRS in a public meeting. The ATSAC shall provide a letter to the Secretary stating: (1) whether the submitted documents provide a scientifically adequate basis to determine whether the proposed source will with reasonable probability injure human health and (2), if the documents do provide an adequate basis, whether the proposed source will with reasonable probability injure human health. If the documents are scientifically inadequate, the ATSAC shall return them to the Department and indicate their inadequacies.

(3) The Department will make a final decision on the issuance of the permit after consideration of the following factors:

(a) The nature of the toxic air pollutant and the size, susceptibility, and proximity of the human population;

(b) The pathways of human exposure (e.g., ingestion, inhalation, skin absorption);

(c) The short term and long term health effects associated with the toxic air pollutant at levels of exposure commensurate with the anticipated exposure level;

(d) Existing epidemiological data on health effects associated with the anticipated levels of exposure;

(e) The character of the land use of the predicted area of impact (e.g., residential, industrial, and recreational); and

(f) The scientific adequacy of the health and environmental assessment submitted by the applicant and the recommendation of the ATSAC. The Department shall not rely on the OEL or on the administrative screening level of one one-hundredth the OEL, and it shall not be bound by prior permit decisions when considering pending applications.

(4) The Department shall deny any application for a permit evaluated under Subsection C of 20.2.72.405 NMAC if the source will emit a toxic air pollutant in such quantities and duration as may with reasonable probability injure human health.

D. The Department shall document, in the administrative record, all processes, facts, and reasoning relied on in making the permit decision, including citations to the relevant technical data, publications, and expert opinions considered.

(1) The final deliberations of the ATSAC shall be open to the public. Except for requests by members of the ATSAC for input from the applicant or Department, no other comments from the applicant, Department, or audience shall be allowed during final deliberations.

(2) Prior to a final decision, the ATSAC members may communicate among themselves in order to facilitate the evaluation process. However, all ATSAC members shall be apprised of such communications.

(3) Prior to a final decision, the ATSAC members may also communicate with the Department and applicant in order to clarify information or secure additional information concerning the applicant's health assessment or the Department's SRS. The Department, applicant, and all ATSAC members shall be apprised of such communication.

[20.2.72.405 NMAC - Rn & A, 20 NMAC 2.72.IV.405, 2/2/01]

20.2.72.406- 20.2.72.499 [RESERVED]

20.2.72.500 TABLE 1 - SIGNIFICANT AMBIENT CONCENTRATIONS

<u>Pollutant</u>	<u>Averaging Time</u>

Total Suspended Particulate	1.0 ug/m3	(Annual)
	5.0 ug/m3	(24-hour)
PM10	1.0 ug/m3	(Annual)
	5.0 ug/m3	(24-hour)
Sulfur Dioxide	1.0 ug/m3	(Annual)
	5.0 ug/m3	(24-hour)
	25.0 ug/m3	(3-hour)
Hydrogen Sulfide	1.0 ug/m3	(1-hour)
	5.0 ug/m3	(1/2-hour)
Carbon Monoxide	0.5 mg/m3	(8-hour)
	2.0 mg/m3	(1-hour)
Nitrogen Dioxide	1.0 ug/m3	(Annual)
	5.0 ug/m3	(24-hour)
Non-Methane Hydrocarbons	5.0 ug/m3	(3-hour)

[20.2.72.500 NMAC - Rn & A, 20 NMAC 2.72.V.500, 2/2/01]

20.2.72.501 TABLE 2 - PERMIT STREAMLINING SOURCE CLASS CATEGORIES

1. Reciprocating internal combustion engines including portable or temporary engines
2. Turbines

[20.2.72.501 NMAC - Rn & A, 20 NMAC 2.72.V.501, 2/2/01]

20.2.72.502 TOXIC AIR POLLUTANTS AND EMISSIONS

Table A- Noncarcinogens

SUBSTANCE	OEL mg/m3	Emissions in pounds per hour
Acetic acid	25.0	1.67
Acetic anhydride	20.0	1.33
Acetylene dichloride, See 1,2-Dichloroethylene		
Acetylene tetrabromide	15.0	1.00
Acetylsalicylic acid	5.00	0.333
Aldrin	0.25	0.0167
Allyl alcohol	5.00	0.333
Allyl glycidol ether	22.0	1.47
Allyl propyl disulfide	12.0	0.800
Aluminum		
metal & oxide	10.0	0.667
pyro powders	5.00	0.333
welding fumes	5.00	0.333
soluble salts	2.00	0.133
alkyls not otherwise classified	2.00	0.133
2-Aminoethanol, See Ethanolamine		
2-Aminopyridine	2.00	0.133
3-Amino 1, 2, 4-triazole, See Amitrole		
Amitrole	0.200	0.0133
Ammonia	18.0	1.20
Ammonium chloride fume	10.0	0.667
Ammonium sulfamate	10.0	0.667
n-Amyl acetate	530	35.3
Sec-Amyl acetate	665	44.3
Aniline homologues	10.0	0.667
Anisidine (p-isomer)	0.500	0.0333
Antimony as Sb	0.500	0.0333
ANTU	0.300	0.0200
Asphalt (petroleum) fumes	5.00	0.333
Atrazine	5.00	0.333
Azinphos-methyl	0.200	0.0133
Barium, soluble compounds, as Ba	0.500	0.0333
Benomyl	10.00	0.667
Benzoyl peroxide	5.00	0.333
Bismuth telluride	10.0	0.667
Se-doped	5.00	0.333
Borates, tetra, sodium salts		
anhydrous	1.00	0.0667
decahydrate	5.00	0.333
pentahydrate	1.00	0.0667
Boron oxide	10.0	0.667
Boron tribromide	10.0	0.667
Boron trifluoride	3.00	0.200
Bromacil	10.0	0.667
Bromine	0.700	0.0467
Bromine pentafluoride	0.700	0.0467
Bromochloromethane, see Chlorobromomethane		

Butanethiol, see Butyl mercaptan		
2-Butoxyethanol	120	8.00
n-Butyl acetate	710	47.3
sec-Butyl acetate	950	63.3
tert-Butyl acetate	950	63.3
Butyl acrylate	55.0	3.67
n-Butyl alcohol	150	10.0
Sec-Butyl alcohol	305	20.3
tert-Butyl alcohol	300	20.0
Butylamine	15.0	1.00
tert-Butyl chromate, as CrO3	0.100	0.00667
n-Butyl glycidol ether (BGE)	135	9.00
n-Butyl lactate		25.0
Butyl mercaptan	1.50	0.10
o-sec-Butylphenol	30.0	2.00
p-tert-Butyltoluene	60	4.00
Cadmium Dusts as Cd	0.0500	0.00333
fume as Cd	*0.0500*	*0.00333*
Calcium hydroxide	5.00	0.333
Calcium oxide	2.00	0.133
Camphor, synthetic	12.0	0.800
Captafol	*0.100*	*0.00667*
Carbofuran	0.100	0.00667
Carbon black	3.50	0.233
Carbon tetrabromide	1.40	0.0933
Carbonyl fluoride	5.00	0.333
Cesium hydroxide	2.00	0.133
Chlorinated diphenyl oxide	0.500	0.0333
Chlorine dioxide	0.300	0.0200
Chlorine trifluoride	0.400	0.0267
Chloroacetaldehyde	3.00	0.200
a-Chloroacetophenone	0.300	0.0200
Chloroacetyl chloride	0.200	0.0133
O-Chlorobenzylidene malononitrile	0.400	0.0267
Chlorobromomethane	1050	70.0
2-Chloro-1,3-butadiene, see B-Chloroprene		
Chlorodiphenyl (42% chlorine)	1.00	0.0667
Chlorodiphenyl (54% chlorine)	0.500	0.033
2-Chloroethanol, see Ethylene chlorohydrin		
1-Chloro-1-nitropropane	10.0	0.667
Chloropicrin	0.700	0.0467
o-Chlorostyrene	285	19.0
o-Chlorotoluene	250	16.7
2-Chloro-6-(trichloromethyl)pyridine, see Nitrapyrin		
Chlorpyrifos	0.200	0.0133
Chromium metal	0.500	0.0333
Clopidol	10.0	0.667
Cobalt as Co	0.100	0.00667
metal, dust & fume	0.100	0.00667
Copper		
fume	0.200	0.0133
dusts & mists, as Cu	1.00	0.0667
Cotton dust, raw	0.200	0.0133
Crotonaldehyde	6.00	0.400
Crufomate	5.00	0.333

Cyanamide	2.00	0.133
Cyanogen	20.0	1.33
Cyanogen chloride	0.600	0.0400
Cyclohexane	1050	70.0
Cyclohexanol	200	13.3
Cyclohexanone	100	6.67
Cyclohexene	1015	67.7
Cyclohexylamine	40.0	2.67
Cyclonite	1.50	0.100
Cyclopentadiene	200	13.3
Cyhexatin	5.00	0.333
DDT (Dichlorodiphenyl trichloroethane)	1.00	0.0667
Decaborane	0.300	0.0200
Demeton	0.100	0.00667
Diacetone alcohol	240	16.0
1,2-Diaminoethane See Ethylenediamine		
Diazinon	0.100	0.00667
Diborane	0.100	0.00667
2-N-Dibutylaminoethanol	14.0	0.933
Dibutyl phosphate	5.00	0.333
Dichloroacetylene	0.400	0.0267
o-Dichlorobenzene	300	20.0
1,3-Dichloro-5,5-dimethyl hydantoin	0.200	0.0133
1,2-Dichloroethylene	790	52.7
Dichlorofluoromethane	40.0	2.67
1,1-Dichloro-1-nitroethane	10.0	0.667
2,2-Dichloropropionic acid	6.00	0.400
Dicrotophos	0.250	0.0167
Dicyclopentadiene	30.0	2.00
Dicyclopentadienyl iron	10.0	0.667
Dieldrin	0.250	0.167
Diethylamine	30.0	2.00
2-Diethylaminoethanol	50.0	3.33
Diethylene triamine	4.00	0.267
Diethyl ether, see Ethyl ether		
Diethyl Ketone	705	47.0
Diethyl phthalate	5.00	0.333
Difluorodibromomethane	860	57.3
Diglycidal ether (DGE)	0.500	0.0333
Diisobutyl ketone	250	16.7
Diisopropylamine	20.0	1.33
Dimethyl acetamide	35.0	2.33
Dimethylamine	18.0	1.20
Dimethylaminobenzene, see Xylidene		
Dimethyl-1,2-dibromo-2-dichloroethyl phospate, see Naled		
2,6-Dimethyl-4-heptanone, see Diisobutyl ketone		
Dinitolmide	5.00	0.333
Dinitrobenzene (all isomers)	1.00	0.0667
3,5-Dinitro-o-toluamide, see Dinitolmide		
Dioxathion	0.200	0.0133
Diphenylamine	10.0	0.667
Diphenylmethane diisocyanate, see Methylene bisphenyl isocyanate		
Dipropylene glycol methyl ether	600	40.0
Dipropyl ketone	235	15.7
Diquat	0.500	0.0333

Disulfiram	2.00	0.133
Disulfoton	0.100	0.00667
2,6-Ditert. butyl-p-cresol	10.0	0.667
Diuron	10.0	0.667
Divinyl benzene	50.0	3.33
Endosulfan	0.100	0.00667
Endrin	0.100	0.00667
Enzymes, see Subtilisins		
EPN	0.500	0.0333
2,3-Epoxy-1-propanol, see Glycidol		
Ethanethiol, see Ethyl mercaptan		
Ethanolamine	8.0	0.533
Ethion	0.400	0.0267
Ethyl acetate	1400	93.3
Ethylamine	18.0	1.20
Ethyl amyl ketone	130	8.67
Ethyl bromide	890	59.3
Ethyl butyl ketone	230	15.3
Ethylene chlorohydrin	3.00	0.200
Ethylenediamine	25.0	1.67
Ethyl ether	1200	80.0
Ethy formate	300	20.0
Ethylidene norbornene	25.0	1.67
Ethyl mercaptan	1.00	0.0667
N-Ethylmorpholine	23.0	1.53
Ethyl silicate	85.0	5.67
Fenamiphos	0.100	0.00667
Fensulfothion	0.100	0.00667
Fenthion	0.200	0.0133
Ferbam	10.0	0.667
Ferrovanadium dust	1.00	0.0667
Fluorides, as F	2.50	0.167
Fluorine	2.00	0.133
Fonofos	0.100	0.00667
Formamide	30.0	2.00
Formic acid	9.00	0.600
Furfural	8.00	0.533
Furfuryl alcohol	40.0	2.67
Gasoline	900	60.0
Germanium tetrahydride	0.600	0.0400
Glutaraldehyde	0.700	0.0467
Glycidol	75.0	5.00
Hafnium	0.500	0.033
2-Heptanone, see Methyl n-amyl ketone		
3-Heptanone, see Ethyl butyl ketone		
Hexachloronaphthalene	0.200	0.0133
Hexfluoroacetone	0.700	0.0467
2-Hexanone, see Methyl n-butyl ketone		
sec-Hexyl acetate	300	20.0
Hexylene glycol	125	8.33
Hydrogenated terphenyls	5.00	0.333
Hydrogen bromide	10.0	0.667
Hydrogen peroxide	1.50	0.100
4-Hydroxy-4-Methyl-2-pentanone, see Diacetone alcohol		
2-Hydroxypropyl acrylate	3.00	0.200

Indene	45.0	3.00
Indium & compounds as In	0.100	0.00667
Iodine	1.00	0.0667
Iodoform	10.0	0.667
Iron oxide fume (Fe2O3) as Fe	5.00	0.333
Iron pentacarbonyl as Fe	0.800	0.0533
Iron salts, soluble, as Fe	1.00	0.0667
Isoamyl acetate	525	35.0
Isoamyl alcohol	360	24.0
Isobutyl acetate	700	46.7
Isobutyl alcohol	150	10.0
Isoocytl alcohol	270	18.0
Isophorone diisocyanate	0.0900	0.00600
Isopropoxyethanol	105	7.00
Isopropyl acetate	950	63.3
Isopropyl alcohol	980	65.3
Isopropylamine	12.0	0.800
N-Isopropylaniline	10.0	0.667
Isopropyl ether	1050	70.0
Isopropyl glycidyl ether (IGE)	240	16.0
Ketene	0.900	0.0600
Lithium hydride	0.0250	00167
Magnesium oxide fume	10.0	0.667
Malathion	10.0	0.667
Manganese as Mn		
dust	5.00	0.333
fume	1.00	0.0667
Mesityl oxide	60	4.00
Methacrylic acid	70.0	4.67
Methanethiol, see Methyl mercaptan		
Methomyl	2.50	0.167
4-Methoxyphenol	5.00	0.333
Methyl acetate	610	40.7
Methyl acrylate	35.0	2.33
Methylacrylonitrile	3.00	0.200
Methylamine	12.0	0.800
Methyl amyl alcohol, see Methyl isobutyl carbinol		
Methyl n-amyl ketone	235	15.7
N-Methyl aniline	2.00	0.133
Methyl n-butyl ketone	20.0	1.33
Methyl 2-cyanoacrylate	8.00	0.533
Methylcyclohexanol	235	15.7
o-Methylcyclohexanone	230	15.3
Methyl demeton	0.500	0.033
Methylene bisphenyl isocyanate (MDI)	0.200	0.0133
Methylene bis(4-cyclohexylisocyanate)	0.110	0.00733
Methyl ethyl ketone peroxide	1.50	0.100
Methyl formate	250	16.7
5-Methyl-3-heptanone, see Ethyl amyl ketone		
Methyl isoamyl ketone	240	16.0
Methyl isobutyl carbinol	100	6.67
Methyl isopropyl ketone	705	47.0
Methyl mercaptan	1.00	0.0667
Methyl parathion	0.200	0.0133
Methyl propyl ketone	700	46.7

Methyl silicate	6.00	0.400
a-Methyl styrene	240	16.0
Metribuzin	5.00	0.333
Mevinphos	*0.100*	*0.00667*
Molybdenum as Mo		
soluble compounds	5.00	0.333
insoluble compounds	10.0	0.667
Moncrotophos	0.250	0.0167
Morpholine	70.0	4.67
Naled	3.00	0.2
Nickel Metal	1.00	0.0667
Nicotine	0.500	0.0333
Nitrapyrin	10.0	0.667
Nitric acid	5.00	0.333
p-Nitroaniline	3.00	0.200
p-Nitrochlorobenzene	3.00	0.200
Nitroethane	310	20.7
Nitrogen trifluoride	300	2.00
Nitroglycerin	0.500	0.00333
Nitromethane	250	16.7
1-Nitropropane	*90.0*	*6.00*
Nitrotoluene	11.0	0.733
Nitrotrichloromethane, see Chloropicrin		
Nonane	1050	70.0
Octachloronaphthalene	0.100	0.0067
Octane	1450	96.7
Oil mist, mineral	5.00	0.333
Osmium tetroxide as Os	0.00200	0.000133
Oxalic acid	1.00	0.0667
Oxygen difluoride	0.100	0.00667
Paraffin wax fume	2.00	0.133
Paraquat respirable sizes	0.100	0.00667
Pentaborane	0.0100	0.000667
Pentachloronaphthalene	0.500	0.0333
2-Pentanone, see Methyl propyl ketone		
Perchloromethyl mercaptan	0.800	0.0533
Perchloryl fluoride	14.0	0.933
Phenacyl chloride, see a-Chloroacetophenone		
Phenothiazine	5.00	0.333
Phenyl ether, vapor	7.00	0.467
Phenyl glycidyl ether (PGE)	6.00	0.400
Phenyl mercaptan	2.00	0.133
Phenylphosphine	0.250	0.0167
Phorate	0.0500	0.00333
Phosdrin, see Mevinphos		
Phosphoric acid	1.00	0.0667
Phosphorus oxychloride	0.600	0.0400
Phosphorus pentachloride	1.00	0.0667
Phosphorus pentasulfide	1.00	0.0667
Phosphorus trichloride	1.50	0.100
m-Phthalodinitrile	5.00	0.333
Picloram	10.0	0.667
Picric acid	0.100	0.00667
Pindone	0.100	0.00667
Piperazine dihydrochloride	5.00	0.333

2-Pivalyl-1,3-indandione, see Pindone		
Platinum		
metal	1.00	0.0667
soluble salts, as Pt	0.00200	0.000133
Potassium hydroxide	2.00	0.133
Propargyl alcohol	2.00	0.133
Propionic acid	30.0	2.00
n-Propyl acetate	840	56.0
Propyl alcohol	500	33.3
Propylene glycol dinitrate	0.300	0.200
n-Propyl nitrate	105	7.00
Pyrethrum	5.00	0.333
Pyridine	15.0	1.00
RDX, see Cyclonite		
Resorcinol	45.0	3.00
Rhodium		
metal	1.00	0.0667
insoluble compounds, as Rh	*1.00*	0.0667
soluble compounds, as Rh	0.0100	0.000667
Ronnel	10.0	0.667
Rotenone (commercial)	5.00	0.333
Selenium as Se	0.200	0.0133
Sesone	10.0	0.667
Silane, see silicon tetrahydride		
Silicon tetrahydride	7.00	0.467
Silver		
metal	0.100	0.00667
soluble compounds, as Ag	0.0100	0.000667
Sodium azide	0.300	0.0200
Sodium bisulfite	5.00	0.333
Sodium 2,4-dichloro-phenoxyethyl sulfate, see Sesone		
Sodium fluoroacetate	0.0500	0.00333
Sodium hydroxide	2.00	0.133
Sodium metabisulfite	5.00	0.333
Stibine	0.500	0.0333
Stoddard solvent	525	35.0
Strychnine	0.150	0.0100
Subtilisins (Proteolytic enzymes as 100% pure crystalline enzyme)	6.00E-05	4.00E-06
Sulfotep	0.200	0.0133
Sulfuric acid	1.00	0.0667
Sulfur monochloride	6.00	0.400
Sulfur pentafluoride	0.100	0.00667
Sulfur tetrafluoride	0.400	0.0267
Sulfuryl fluoride	20.0	1.33
Sulprofos	1.00	0.0667
Systox, see Demeton		
2,4,5-T	10.0	0.667
Tantalum	5.00	0.333
TEDP, see Sulfotep		
Tellurium & Compounds as Te	0.100	0.00667
Tellurium hexafluoride as Te	0.200	0.0133
Temephos	10.0	0.667
TEPP	0.0500	0.00333
Terphenyls	5.00	0.333

Tetrachloronaphthalene	2.00	0.133
Tetramethyl succinoitrile	3.00	0.200
Tetranitromethane	8.00	0.533
Tetrasodium pyrophosphate	5.00	0.333
Tetryl	1.50	0.100
Thallium, soluble compounds, as Tl	0.100	0.00667
4,4-Thiobis (6 tert, butyl-m-cresol)	10.0	0.667
Thioglycolic acid	4.00	0.267
Thionyl chloride	5.00	0.333
Thiram	5.00	0.333
Tin		
metal	2.00	0.133
oxide & inorganic compounds, except SnH4, as Sn	2.00	0.133
organic compounds as Sn	0.100	0.00667
m-Toluidine	9.00	0.600
Tributyl phosphate	2.50	0.167
Trichloroacetic acid	7.00	0.467
Trichloronaphthalene	5.00	0.333
Trichloronitromethane, See Chloropicrin		
1,2,3-Trichloropropane	300	20.0
Tricyclohexyltin hydroxide, see Cyhexatin		
Trimellitic anhydride	0.0400	0.00267
Trimethylamine	24.0	1.60
Trimethyl benzene	125	8.33
Trimethyl phosphite	10.0	0.667
2,4,6-Trinitrophenol, see Picric acid		
2,4,6-Trinitrophenylmethylnitramine, see Tetryl		
2,4,6-Trinitrotoluene (TNT)	0.500	0.0333
Triorthosresyl phosphate	0.100	0.00667
Triphenyl amine	5.00	0.333
Triphenyl phosphate	3.00	0.200
Tungsten as W		
insoluble compounds	5.00	0.333
soluble compounds	1.0	37.3
Turpentine	560	37.3
Uranium (natural) soluble & insoluble compounds as U	0.200	0.0133
n-Valeraldehyde	175	11.7
Vanadium, as V2O5 respirable dust & fume	0.0500	0.00333
Vinyl toluene	240	16.0
VM & P Naphtha	1350	90.0
Warfarin	0.100	0.00667
Wood dust (certain hard woods as beech & oak)	1.00	0.0667
soft wood	5.00	0.333
m-Xylene a,a-diamine	0.100	0.00667
Xylidine	10.0	0.667
Yttrium	1.00	0.0667
Zinc chloride fume	1.00	0.0667
Zinc oxide fume	5.00	0.333
Zirconium compounds as Zr	5.00	0.333

Table B - Known or Suspected Carcinogens

SUBSTANCE	OEL mg/m3	Emissions in pounds per hour
Coal tar volatiles, as benzene solubles	0.200	0.0133
B-Naphthylamine	0.00300*	2.00E-04
N-Phenyl-beta-naphthylamine	5.00**	0.333
Phenylhydrazine	20.0	1.33
o-Tolidine	11.0**	0.733
p-Toluidine	9.00	0.600
Vinyl cyclohexene dioxide	60.0	4.00

FOOTNOTES

The emissions in pounds per hour in Section 502 were derived using the formula listed below:

emission level (lbs/hr) = OEL (mg/m3) / 15

* = Compound for which an OEL is not listed by the ACGIH. Value derived by using the miminum detectable level listed in the NIOSH "Manual of Analytical Methods", Third Edition.

** = Compound for which an OEL is not listed by the ACGIH and for which there is no chemical specific analytical method listed in the NIOSH "Manual of Analytical Methods", Third Edition. A minimum dectable level (MDL) was derived by using the MDL of a similar compound listed in the NIOSH analytical methods or by assigning the average MDL for a class of compounds such as "halogenated hydrocarbons". In some cases the lowest MDL of the whole class was used.

Table C - Stack Height Release Correction Factor

Sources may choose to use a correction factor for the release height of emissions for the purpose of determining whether a permit is necessary for the emission of a toxic air pollutant. To apply the correction go to the table below and find the minimum height of release for the toxic air pollutant and *select the correction factor (CF) which corresponds to that figure. If the height of release is between two* values, the lower number shall be selected; or in the event of multiple releases of the same substance from different release heights, the source may choose to use a weighted average CF, weighted by the emission rate at each. The emissions in pounds per hour is then multiplied by the CF (see below). If the emissions from your source exceed the resulting number, you must apply for a permit from the Department. Remember, this must be done for each toxic air pollutant.

CF x *Emissions in Pounds per Hour*

where: E - emission rate (pounds per hour)

OEL - occupational exposure limit (mg per cubic meter)

CF is a correction factor, shown in the table below, which accounts for release height.

Release Height in Meters	Correction Factor (CF)*
Less than 3	1
10	5
20	19
30	41
40	71
50	108
60	152
70	202
80	255
90	317
100	378
110	451
120	533
130	617
140	690
150	781
160	837
170	902
180	1002
190	1066
200	1161

[20.2.72.502 NMAC - Rn & A, 20 NMAC 2.72.V.502, 2/2/01]

HISTORY OF 20.2.72 NMAC:
Pre-NMAC History: The material in this part was derived from that previously filed with the Commission of Public Records-State Records Center and Archives.
AQCR 702, Permits, 07/31/72.
EIB/AQCR 702, Permits, 08/18/87.
EIB/AQCR 702, Permits, 10/19/88.
EIB/AQCR 702, Permits, 05/29/90.
EIB/AQCR 702, Permits, 04/12/94.
EIB/AQCR 702, Permits, 05/13/94.

History of Repealed Material: [RESERVED]

Other History:
EIB/AQCR 702, Permits, filed 05/13/94, was **renumbered** into first version of the New Mexico Administrative Code as 20 NMAC 2.72, Construction Permits, effective 11/30/95.
20 NMAC 2.72, Construction Permits, filed 10/30/95, was **renumbered, reformatted and replaced** by

20.2.72 NMAC, Construction Permits, effective 02/02/01.

PART 73
NOTICE OF INTENT AND EMISSIONS INVENTORY REQUIREMENTS

20.2.73.1 ISSUING AGENCY:
Environmental Improvement Board.
[11/30/95; 20.2.73.1 NMAC - Rn, 20 NMAC 2.73.100 02/18/02]

20.2.73.2 SCOPE:
All persons who own or operate a source or who intend to construct or modify a source.
[11/30/95; 20.2.73.2 NMAC - Rn, 20 NMAC 2.73.101 02/18/02]

20.2.73.3 STATUTORY AUTHORITY:
Environmental Improvement Act, NMSA 1978, Section 74-1-8(A)(4), and Air Quality Control Act, NMSA 1978, Sections 74-2-1 et seq., including specifically, Section 74-2-7(A)(1) and (B).
[11/30/95; 20.2.73.3 NMAC - Rn, 20 NMAC 2.73.102 02/18/02]

20.2.73.4 DURATION:
Permanent.
[11/30/95; 20.2.73.4 NMAC - Rn, 20 NMAC 2.73.103 02/18/02]

20.2.73.5 EFFECTIVE DATE:
November 30, 1995 except where a later date is cited at the end of a section or paragraph.
[11/30/95, 10/01/97; 20.2.73.5 NMAC - Rn, 20 NMAC 2.73.104 02/18/02]
[The latest effective date of any section in this Part is January 1, 2008.]

20.2.73.6 OBJECTIVE:
The objective of this part is to establish requirements for the submission of certain relevant information to ensure that the regulations and standards under the Air Quality Control Act and the federal act will not be violated, and to facilitate the quantification of greenhouse gas emissions in New Mexico.
[11/30/95; 20.2.73.6 NMAC - Rn, 20 NMAC 2.73.105 02/18/02; A, 01/01/08]

20.2.73.7 DEFINITIONS:
In addition to the terms defined in 20.2.2 NMAC (Definitions), as used in this part, the following apply.

A. **"Air pollution control equipment"** means any device, equipment, process or combination thereof the operation of which would limit, capture, reduce, confine, or otherwise control air contaminants or convert for the purposes of control any air contaminant to another form, another chemical or another physical state.

B. **"California climate action registry"** means the voluntary registry for greenhouse gas

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emissions established pursuant to California Health & Safety Code D. 26, Pt. 4, Ch. 6 (West 2007).

C. **"Commencement"** means that an owner or operator has undertaken a continuous program of construction or modification.

D. **"Construction"** means fabrication, erection, installation or relocation of a stationary source, including but not limited to temporary installations and portable stationary sources.

E. **"Emission report or inventory"** means a listing, by source, of the amount of air pollutants discharged into the atmosphere of a community.

F. **"Fuel carbon content"** means the mass of carbon per unit of heat content of a fuel.

G. **"Fugitive emissions"** are those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening.

H. **"Greenhouse gas emissions reporting year"** means the calendar year in which greenhouse gas emissions required to be reported under this part occurred.

I. **"Modification"** means any physical change in, or change in the method of operation of, a stationary source which results in an increase in the potential emission rate of any regulated air contaminant emitted by the source or which results in the emission of any regulated air contaminant not previously emitted, but does not include:

(1) a change in ownership of the source;

(2) routine maintenance, repair or replacement;

(3) installation of air pollution control equipment, and all related process equipment and materials necessary for its operation, undertaken for the purpose of complying with regulations adopted *by the board or pursuant to the federal Clean Air Act; or*

(4) unless previously limited by enforceable permit conditions:

(a) an increase in the production rate, if such increase does not exceed the operating design capacity of the source;

(b) an increase in the hours of operation; or

(c) use of an alternative fuel or raw material if, prior to January 6, 1975, the source was capable of accommodating such fuel or raw material, or if use of an alternate fuel or raw material is caused by any natural gas curtailment or emergency allocation or any other lack of supply of natural gas.

J. **"Nonattainment area"** means, for any air pollutant, an area which has been designated as a nonattainment area under Section 107 of the federal act.

K. **"Operator"** means the person or persons responsible for the overall operation of a facility.

L. **"Owner"** means the person or persons who own a facility or part of a facility.

M. **"Part"** means an air quality control regulation under Title 20, Chapter 2 of the New Mexico administrative code, unless otherwise noted; as adopted or amended by the board.

N. **"Portable stationary source"** means a source which can be relocated to another operating site with limited dismantling and reassembly, including for example but not limited to moveable sand and gravel processing operations and asphalt plants.

O. **"Potential emission rate"** means the emission rate of a source at its maximum capacity to emit a regulated air contaminant under its physical and operational design, provided any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored or processed, shall be treated as part of its physical and operational design only if the limitation or the effect it would have on emissions is enforceable by the department pursuant to the Air Quality Control Act or the federal act.

P. **"Potential to emit"** means the maximum capacity of a stationary source to emit any air pollutant under its physical and operational design; any physical or operational limitation on the capacity of a source to emit an air pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation is federally enforceable; the potential to emit for nitrogen dioxide shall be based on total oxides of nitrogen.

Q. **"Regulated air contaminant"** means any air contaminant, the emission or ambient concentration of which is regulated pursuant to the New Mexico Air Quality Control Act or the federal act.

R. **"Shutdown"** means the cessation of operation of any air pollution control equipment, process equipment or process for any purpose, except routine phasing out of batch process units.

S. **"Stationary source"** or "source" means any building, structure, equipment, facility, installation (including temporary installations), operation or portable stationary source which emits or may emit any air contaminant; any research facility may group its sources for the purpose of this part at the discretion of the secretary of the department.

T. **"The climate registry"** means the nonprofit corporation by that name incorporated under the District of Columbia Nonprofit Corporation Act with a purpose of creating and operating a multi-state greenhouse gas emissions registry.

U. **"WEB source"** means a stationary source that meets the applicability requirements of 20.2.81.101 NMAC.

V. **"Western backstop sulfur dioxide trading program"** means 20.2.81 NMAC, triggered as a backstop in accordance with the provisions in the sulfur dioxide milestones and backstop trading program implementation plan, if necessary, to ensure that regional sulfur dioxide emissions are reduced.

[11/30/95, 10/01/97; 20.2.73.7 NMAC - Rn, 20 NMAC 2.73.107 & A, 02/18/02; A, 12/31/03; A, 01/01/08]

20.2.73.8 to 20.2.73.105 [RESERVED]

20.2.73.106 AMENDMENT AND SUPERSESSION OF PRIOR REGULATIONS:
This part amends and supersedes Air Quality Control Regulation ("AQCR") 703.1 - Notice of Intent and Emissions Inventory Requirements last filed May 29, 1990, as amended ("AQCR 703.1").

A. All references to AQCR 703.1 in any other rule shall be construed as a reference to this part.

B. The amendment and supersession of AQCR 703.1 shall not affect any administrative or judicial enforcement action pending on the effective date of such amendment nor the validity of any permit issued pursuant to AQCR 703.1.

[11/30/95; 20.2.73.106 NMAC - Rn, 20 NMAC 2.73.106 02/18/02]

20.2.73.107 to 20.2.73.199 [RESERVED]

20.2.73.200 NOTICE OF INTENT:

A. **Applicability:**

(1) Any owner or operator intending to construct a new stationary source which has a potential emission rate greater than 10 tons per year of any regulated air contaminant or 1 ton per year of lead shall file a notice of intent with the department.

(2) Any owner or operator intending to modify a stationary source which either prior to or following the modification has a potential emission rate greater than 10 tons per year of any regulated air contaminant or 1 ton per year of lead shall file a notice of intent with the department.

(3) The requirements of 20.2.73.200 NMAC do not apply to stationary sources or modifications located in Bernalillo county.

(4) The notice of intent shall be filed prior to the commencement of construction. Construction shall not begin prior to issuance of a written determination by the department that a permit is not required, or if a permit is required, prior to the issuance of the permit under 20.2.72 NMAC, 20.2.74 NMAC or 20.2.79 NMAC.

B. Contents of Notice: Notices of intent shall be filed on forms furnished by the department, which shall be identical to the extent practicable, as those used for 20.2.72 NMAC (Construction Permits) and shall include:

(1) The applicant's name and address, the person to contact regarding the application, and the name and address of the new source or modification.

(2) The date of the application.

(3) A description of the new facility or modification including all operations affecting air emissions.

(4) The anticipated operating schedule.

(5) A map such as a 7.5 minute United States geological survey topographic quadrangle showing the location of the stationary source.

(6) The nature and quantities of any regulated air contaminants the new source or modification will emit, including all calculations utilized to estimate emissions.

(7) A description of any air pollution control device or method to be utilized, including the basis for the estimated control efficiency.

(8) The stack and exhaust gas parameters for all emission points.

(9) Any other relevant information as the department may reasonably require.

(10) Be signed under oath or affirmation by the operator, the owner, or an authorized representative, certifying to the best of his or her knowledge the truth of all information submitted.

C. Review of Notice: Within thirty days from the date a notice is received, the department shall review its content and by certified letter indicate to the applicant:

(1) the notice is incomplete and indicate specific additional material or clarification required; or

(2) a permit is not required and construction may commence; or

(3) a permit is required before construction may commence. For this case, the department will indicate whether the application is complete with respect to the requirements of each applicable permit regulation and specify additional material or clarification required if it is not complete.

D. Verification: In verifying information submitted in response to the requirements of this part, the department may:

(1) Enter at all reasonable times in or upon any private or public property, except private residences, which the department has reasonable cause to believe is or will become a source of air contaminants contributing to air pollution; and

(2) Require the production of information relating to emissions which cause or contribute to air pollution, including the sampling of emissions in accordance with methods and at locations and intervals as may be prescribed by the department.

E. Notification Requirements:

(1) The owner or operator of a portable stationary source shall notify the department in writing of the date and site of any relocation at least fifteen days prior to its occurrence.

(2) Any owner or operator of a stationary source which will be shut down for a period of one year or more shall notify the department in writing of the actual date of shut down within thirty days after the shut down occurs.

(3) Any new owner or operator of a stationary source shall notify the department within thirty days of assuming ownership of his or her name and address.

[11/30/95; 20.20.73.200 NMAC - Rn, 20 NMAC 2.73.200-204 02/18/02]

20.2.73.201 to 20.2.73.299 [RESERVED]

20.2.73.300 EMISSION INVENTORY REQUIREMENTS:

A. Applicability. The requirements of 20.2.73.300 NMAC apply to the owner or operator of any stationary source located outside of Bernalillo county which:

(1) has been issued a permit under 20.2.72 NMAC (Construction Permits) during any period of time, except for toxic air pollutant permits issued under Sections 401 to 499 of 20.2.72 NMAC;

(2) is required to file a notice of intent under 20.2.73.200 NMAC; or

(3) emits in excess of 1 ton of lead or 10 tons of total suspended particulate, PM10, PM2.5, sulfur dioxide, nitrogen oxides, carbon monoxide, or volatile organic compounds in any calendar year including and subsequent to 1990.

B. Reporting requirements.

(1) Any source which emits, or has the potential to emit, 5 tons per year or more of lead or lead compounds, or 100 tons per year or more of PM10, PM2.5, sulfur oxides, nitrogen oxides, carbon monoxide, or volatile organic compounds shall submit an emissions report annually.

(2) Any source defined as a major source of hazardous air pollutants under 20.2.70 NMAC (Operating Permits) shall submit an emissions report annually.

(3) Any source which is located in an ozone nonattainment area and which emits, or has the potential to emit, 25 tons per year or more of nitrogen oxides or volatile organic compounds shall submit an emissions report annually.

(4) Any source which is not required by Paragraph (1), (2), or (3) of Subsection B of this section (20.2.73.300 NMAC) to submit an emission report shall submit an emissions report under this part upon request by the department, but no more frequently than annually.

(5) Except as provided in Paragraph (8) of Subsection B of this section (20.2.73.300 NMAC), the department shall provide to the owner or operator required by this section (20.2.73.300 NMAC) to submit an emissions report a complete copy of the most current emissions report for their stationary source which is on file with the department. The department shall provide this copy to the owner or operator at least 90 days prior to the date when the source is required to submit an emissions report.

(6) The owner or operator shall submit to the department a complete, correct and current emissions report in the format specified by the department which reflects emissions during the previous calendar year.

(7) Except as provided in Paragraph (8) of Subsection B of this section (20.2.73.300 NMAC) the owner or operator shall submit the emission report by April 1 of each year in which the source is required to submit an emission report.

(8) Sources for which a date for submitting an annual emission report is specified in a current operating permit issued under 20.2.70 NMAC (Operating Permits) shall submit such report on that date. The department shall provide a copy of the previous emissions report upon request by the owner or operator of such source.

(9) Any source that is requested by the department to submit a report of greenhouse gas emissions shall:

(a) *submit such report on the schedule and according to the greenhouse gas emissions* reporting procedures established by the department, but not more often than annually; or

(b) report greenhouse gas emissions from the source under 20.2.87 NMAC for the greenhouse gas emissions reporting year and the two years following that year; or

(c) provide the department access to the requested information for the greenhouse gas emissions reporting year registered in either the climate registry or the California climate action registry; and

(d) keep records in support of the report for a minimum of five years.

(10) In determining the schedule of greenhouse gas emissions reports and reporting procedures, the department, subject to Paragraph (11) below, shall provide an opportunity for public comment, and shall consider:

(a) public comments regarding the schedule of such reports and greenhouse gas emissions reporting procedures;

(b) emissions quantification standards and best practices approved or recommended by federal and state agencies, by greenhouse gas emissions registries, and by non-governmental bodies having expertise in greenhouse gas emissions quantification;

(c) whether greenhouse gases emissions from a particular source or source type, considering the amount and chemical composition of the emissions, are expected to be minimal relative to emissions from other sources or source types, and

(d) whether emissions of a particular greenhouse gas from a source or source type, considering the amount and chemical composition of the emissions, are expected to be minimal relative to the total greenhouse gas emissions from that source or source type.

(11) The schedule for greenhouse gas emissions reports and reporting procedures pursuant to Paragraphs (9) and (10) of Subsection B of 20.2.73.300 NMAC, shall:

(a) subject to the department's selection of best available quantification methodologies, include a requirement that sources within North American industry classification system codes 211111, 211112, 213111, 213112, 486210, 221210, 486110, and 486910 subject to this part and permit requirements pursuant to 20.2.70 NMAC (Operating Permits) report at a minimum emissions of carbon dioxide and methane beginning no later than reporting year 2009 and for subsequent reporting years; and

(b) subject to the department's selection of best available quantification methodologies, include a requirement that sources within North American industry classification system codes 211111, 211112, 213111, 213112, 486210, 221210, 486110, and 486910 subject to this part pursuant to Paragraphs (1) and (2) of Subsection A of 20.2.73.300 NMAC, and not otherwise covered by Subparagraph (a), above, report at a minimum emissions of carbon dioxide and methane no later than reporting year 2010 and for subsequent reporting years as requested by the Department.

C. Content of emissions reports. Emissions report contents for reports made under Paragraphs (1) through (8) of Subsection B of 20.2.73.300 NMAC shall include:

(1) the name, address, if any, and physical location of the stationary source;

(2) the name and telephone number of the person to contact regarding the emissions report;

(3) a certification signed by the owner, or operator, or a responsible official as defined in

20.2.70 NMAC attesting that the statements and information contained in the emissions report are true and accurate to the best knowledge and belief of the certifying official, and including the full name, title, signature, date of signature, and telephone number of the certifying official; for sources subject to 20.2.70 NMAC, the certification shall be made as required under that part;

(4) smelters shall submit an annual report of sulfur input, in tons/year;

(5) for each emission point, as required by the department:

(a) stack and exhaust gas parameters and location information;

(b) type of control equipment and estimated control efficiency;

(c) schedule of operation;

(d) estimated actual emissions, including fugitive emissions and emissions occurring during maintenance, start-ups, shutdowns, upsets, and downtime of total suspended particulate, PM10, PM2.5, ammonia, sulfur oxides, nitrogen oxides, carbon monoxide, volatile organic compounds, and lead, and, if requested by the department, speciated hazardous air pollutants, in tons per year and a description of the methods utilized to make such estimates, including calculations;

(e) the annual process or fuel combustion rates; and

(f) the fuel heat, sulfur, and ash content; and

(6) all information required under the federal act.

D. Additional content for emissions reports from sources in ozone nonattainment areas. Emissions reports from sources located in ozone nonattainment areas shall include, in addition to the contents specified by Subsection C of this section (20.2.73.300 NMAC), the following information:

(1) typical daily process rate during the peak ozone season, where the peak ozone season is specified by the department; and

(2) estimated actual emissions of nitrogen oxides and volatile organic compounds, which shall be reported:

(a) for each emissions point;

(b) for each process and fuel type contributing to emissions from each point;

(c) in units of tons per year for annual emissions; and

(d) in units of pounds per day for a typical day during the peak ozone season.

E. Waiver of reporting requirements for insignificant emissions. The department may waive the requirements of Paragraph (5) of Subsection C of this section (20.2.73.300 NMAC) for emissions which the department determines to be insignificant under 20.2.70 NMAC, except that:

(1) for sources in nonattainment areas, reporting of emissions of pollutants for which the area is nonattainment shall not be waived; and

(2) reporting of emissions for which reporting is required under the federal act shall not be waived.

F. Emission tracking requirements for sulfur dioxide emission inventories. All stationary sources with actual emissions of one hundred (100) tons per year or more of sulfur dioxide in the year 2000, or in any subsequent year, shall submit an annual inventory of sulfur dioxide emissions, beginning with the 2003 emission inventory. A source that meets these criteria that then emits less than 100 tons per year in a later year shall submit a sulfur dioxide inventory for tracking compliance with the regional sulfur dioxide milestones until the western backstop sulfur dioxide trading program has been fully implemented and emission tracking has occurred under 20.2.81.106 NMAC.

(1) All WEB sources will be subject to the following federally enforceable provisions:

(a) submit an annual inventory of sulfur dioxide emissions;

(b) document the emissions monitoring/estimation methodology used, and demonstrate that the selected methodology is acceptable under the inventory program;

(c) include emissions from start up, shut down, and upset conditions in the annual total inventory;

(d) use 40 CFR Part 75 methodology for reporting emissions for all sources subject to the federal acid rain program;

(e) maintain all records used in the calculation of the emissions, including but not limited to the following:

(i) amount of fuel consumed;

(ii) percent sulfur content of fuel and how the content was determined;

(iii) quantity of product monitoring data;

(iv) emissions monitoring data;

(v) operating data; and

(vi) how the emissions are calculated;

(f) maintain records of any physical changes to facility operations or equipment, or any other changes that may affect the emissions projections; and

(g) retain records for a minimum of ten years from the date of establishment, or if the record was the basis for an adjustment to the milestone, five years after the date of an implementation plan revision, whichever is longer.

(3) The department shall retain emission inventory records for non-utilities for 2006 until the year 2018 to ensure that changes in emissions monitoring techniques can be tracked.

G. Content of greenhouse gas emissions reports. Greenhouse gas emissions reports shall contain the following information, as set out in the greenhouse gas emissions reporting procedures established under Subparagraph (a) of Paragraph (9) of Subsection B of 20.2.73.300 NMAC:

(1) the name, location, and permit or notice of intent number of the stationary source;

(2) the name and telephone number of the person to contact regarding the greenhouse gas emissions report;

(3) a certification signed by the owner or operator attesting that the statements and information contained in the emissions report are true and accurate to the best knowledge and belief of the certifying official, and including the full name, title, signature, date of signature, and telephone number of the certifying official;

(4) for each emission point as required by the department under the greenhouse gas emissions reporting procedures, the estimated actual emissions of greenhouse gases, including fugitive emissions and emissions occurring during maintenance, start-ups, shutdowns, upsets and downtime; and

(5) if requested by the department, the fuel type, fuel heat content, and fuel carbon content.

[11/30/95; 10/01/97; 2.20.73.300 NMAC - Rn, 20 NMAC 2.73.300 - 304 02/18/02; A, 12/31/03; A, 12/31/04; A, 01/01/08; A, 07/06/11]

HISTORY OF 20.2.73 NMAC:

Pre-NMAC History: The material in this part was derived from that previously filed with the commission of public records - state records center and archives.

EIB/AQCR 703.1, Air Quality Control Regulation 703.1 - Notice of Intent and Emissions Inventory Requirements, 5/29/90.

History of Repealed Material: [RESERVED]

Other History:

EIB/AQCR 703.1, Air Quality Control Regulation 703.1 - Notice of Intent and Emissions Inventory Requirements, filed 5/29/90, was **renumbered** into first version of the New Mexico Administrative Code as 20 NMAC 2.73, Notice of Intent and Emissions Inventory Requirements, filed 10/30/95.
20 NMAC 2.73, Notice of Intent and Emissions Inventory Requirements, filed 10/30/95, was **renumbered, reformatted, amended and replaced** by 20.2.73 NMAC, Notice of Intent and Emissions Inventory Requirements, effective 02/18/02.

19.2.10.8 NO RIGHTS TO BE OBTAINED BY PRESCRIPTION:
Easements or rights of way on trust lands may be acquired only by application and grant made in compliance with this part and applicable laws. No easement, right of way, or other interest in trust lands may be acquired by prescription, or pursuant to any other legal doctrine, except as provided by statute.
[19.2.10.8 NMAC - Rp, 19.2.10.8 NMAC, 06/30/04]

EXHIBIT
KK

19.2.10.9 TRESPASS:

A. Any use of trust lands for right of way or easement purposes prior to the grant of a right of way or easement as provided by this Part 10 shall constitute an unauthorized use of such lands and will be deemed a trespass. The use of trust lands for easement or right of way purposes, if based upon any approval by any means other than as provided for in this Part 10, will likewise be deemed a trespass. However, in extenuating circumstances and for good cause shown, the commissioner may, in his discretion and upon written request, waive the trespass penalties set out below when the trespass consists of an inadvertent failure to obtain or renew an easement or right of way and that failure is promptly corrected when discovered.

B. Upon notification or determination that an unauthorized use exists, the commissioner shall initiate criminal or civil trespass sanctions, or both, against the unauthorized user; provided, however, that prior to the initiation of such action, the commissioner may attempt to remedy the trespass non-judicially by such means as he deems best including, but not limited to: 1) offering the unauthorized user the opportunity to terminate the unauthorized use, restore the lands to their condition prior to the unauthorized use, and pay the pro-rated fair market value of the unauthorized use through the date of termination; or, 2) offering to ratify the unauthorized use upon receipt of the required consideration plus the applicable trespass penalty set forth in Subsection D of 19.2.10.9 NMAC below. The commissioner shall not initiate or otherwise pursue criminal or civil trespass sanctions against an unauthorized user if that unauthorized user accepts and complies with any non-judicial remedy offered by the commissioner to remedy the unauthorized use.

C. All time limitations imposed upon an unauthorized user by the commissioner when offering non-judicial remedies shall be reasonable, but in no case shall any such limit be less than 10 days nor more than 60 days.

D. **Trespass penalties:** All trespass penalties are due in addition to the consideration due under 19.2.10.15 NMAC below.

(1) An unauthorized user must pay the following trespass penalty:

(a) for the first occurrence of unauthorized use, 100% of the applicable fair market value;

(b) for the second occurrence, 500% of the applicable fair market value;

(c) for the third occurrence, 1000% of the applicable fair market value;

(d) for the fourth and subsequent occurrences, 1000% of the applicable fair market value and the grant of easement or right of way is limited to a maximum 5-year term at the applicable fair market value for a 35-year term;

(2) Any occurrence of trespass preceded by 5 years of non-occurrence by the party in trespass will be treated as a first occurrence.

(3) In the commissioner's sole discretion, applicable trespass penalties will be reduced by no more than 50% if the trespass is self-reported before the commissioner learns of it from any other source.

(4) The trespass penalties described above apply only to unauthorized uses that commence on or after February 28, 2002. The trespass penalty for an unauthorized use that commenced prior to that date is 100% of the fair market value.

[19.2.10.9 NMAC - Rp, 19.2.10.9 NMAC, 06/30/04]

19.2.10.17 ACCESS PERMITS:
The rights granted by the commissioner in any right of way or easement shall not include any right of access over, or right to use, trust lands not within the actual dimensions of the right of way or easement. If a right of way or easement is not large enough to permit vehicular or other access necessary for the maintenance, repair, or improvement, of the right of way or easement, or for other permitted activities within the right of way or easement, access in such cases must be obtained by applying for and receiving a temporary access permit from the commissioner using such form or forms, and subject to the payment of such fees and costs, as the commissioner deems in the best interests of the trust and promulgates from time to time. Temporary access permits may also be issued to prospective applicants for rights of way or easements to allow them to conduct pre-application assessments. Each entry upon trust lands without an access permit as required by *19.2.10.17* NMAC *shall be a separate trespass under* 19.2.10.9 NMAC *above.*
[19.2.10.17 NMAC - Rp, 19.2.10.17 NMAC, 06/30/04]

20.6.2.3101 PURPOSE:

A. The purpose of Sections 20.6.2.3000 through 20.6.2.3114 NMAC controlling discharges onto or below the surface of the ground is to protect all ground water of the state of New Mexico which has an existing concentration of 10,000 mg/l or less TDS, for present and potential future use as domestic and agricultural water supply, and to protect those segments of surface waters which are gaining because of ground water inflow, for uses designated in the New Mexico Water Quality Standards. Sections 20.6.2.3000 through 20.6.2.3114 NMAC are written so that in general:

(1) if the existing concentration of any water contaminant in ground water is in conformance with the standard of 20.6.2.3103 NMAC, degradation of the ground water up to the limit of the standard will be allowed; and

(2) if the existing concentration of any water contaminant in ground water exceeds the standard of Section 20.6.2.3103 NMAC, no degradation of the ground water beyond the existing concentration will be allowed.

B. Ground water standards are numbers that represent the pH range and maximum concentrations of water contaminants in the ground water which still allow for the present and future use of ground water resources.

C. The standards are not intended as maximum ranges and concentrations for use, and nothing herein contained shall be construed as limiting the use of waters containing higher ranges and concentrations.

[2-18-77; 20.6.2.3101 NMAC - Rn, 20 NMAC 6.2.III.3101, 1-15-01]

EXHIBIT
LL

20.6.2.3103 STANDARDS FOR GROUND WATER OF 10,000 mg/l TDS CONCENTRATION OR LESS:

The following standards are the allowable pH range and the maximum allowable concentration in ground water for the *contaminants specified unless the existing condition exceeds the standard* or unless otherwise provided in Subsection D of Section 20.6.2.3109 NMAC. Regardless of whether there is one contaminant or more than one contaminant present in ground water, when an existing pH or concentration of any water contaminant exceeds the standard specified in Subsection A, B, or C of this section, the existing pH or concentration shall be the allowable limit, provided that the discharge at such concentrations will not result in concentrations at any place of withdrawal for present or reasonably foreseeable future use in excess of the standards of *this section. These standards shall apply to the dissolved portion of the contaminants specified* with a definition of dissolved being that given in the publication "*methods for chemical analysis of water and waste of the U.S. environmental protection agency,*" with the exception that standards for mercury, organic compounds and non-aqueous phase liquids shall apply to the total unfiltered concentrations of the contaminants.

A. **Human Health Standards**-Ground water shall meet the standards of Subsection A and B of this section unless otherwise provided. If more than one water contaminant affecting human health *is present, the toxic pollutant criteria as set forth in the definition of toxic pollutant in Section* 20.6.2.1101 NMAC for the combination of contaminants, or the Human Health Standard of Subsection A of Section 20.6.2.3103 NMAC for each contaminant shall apply, whichever is more stringent. Non-aqueous phase liquid shall not be present floating atop of or immersed within ground water, as can be reasonably measured.

(1)	Arsenic (As)	0.1 mg/l
(2)	Barium (Ba)	1.0 mg/l
(3)	Cadmium (Cd)	0.01 mg/l
(4)	Chromium (Cr)	0.05 mg/l
(5)	Cyanide (CN)	0.2 mg/l
(6)	Fluoride (F)	1.6 mg/l
(7)	Lead (Pb)	0.05 mg/l
(8)	Total Mercury (Hg)	0.002 mg/l
(9)	Nitrate (NO_3 as N)	10.0 mg/l
(10)	Selenium (Se)	0.05 mg/l
(11)	Silver (Ag)	0.05 mg/l
(12)	Uranium (U)	0.03 mg/l
(13)	Radioactivity: Combined Radium-226 & Radium-228	30 pCi/l
(14)	Benzene	0.01 mg/l
(15)	Polychlorinated biphenyls (PCB's)	0.001 mg/l
(16)	Toluene	0.75 mg/l
(17)	Carbon Tetrachloride	0.01 mg/l
(18)	1,2-dichloroethane (EDC)	0.01 mg/l
(19)	1,1-dichloroethylene (1,1-DCE)	0.005 mg/l
(20)	1,1,2,2-tetrachloroethylene (PCE)	0.02 mg/l
(21)	1,1,2-trichloroethylene (TCE)	0.1 mg/l

(22) ethylbenzene..........0.75 mg/l
(23) total xylenes..........0.62 mg/l
(24) methylene chloride..........0.1 mg/l
(25) chloroform..........0.1 mg/l
(26) 1,1-dichloroethane..........0.025 mg/l
(27) ethylene dibromide (EDB)..........0.0001 mg/l
(28) 1,1,1-trichloroethane..........0.06 mg/l
(29) 1,1,2-trichloroethane..........0.01 mg/l
(30) 1,1,2,2-tetrachloroethane..........0.01 mg/l
(31) vinyl chloride..........0.001 mg/l
(32) PAHs: total naphthalene plus monomethylnaphthalenes..........0.03 mg/l
(33) benzo-a-pyrene..........0.0007 mg/l

B. Other Standards for Domestic Water Supply

(1) Chloride (Cl)..........250.0 mg/l
(2) Copper (Cu)..........1.0 mg/l
(3) Iron (Fe)..........1.0 mg/l
(4) Manganese (Mn)..........0.2 mg/l
(6) Phenols..........0.005 mg/l
(7) Sulfate (SO_4)..........600.0 mg/l
(8) Total Dissolved Solids (TDS)..........1000.0 mg/l
(9) Zinc (Zn)..........10.0 mg/l
(10) pH..........between 6 and 9

C. Standards for Irrigation Use - Ground water shall meet the standards of Subsection A, B, and C of this section unless otherwise provided.

(1) Aluminum (Al)..........5.0 mg/l
(2) Boron (B)..........0.75 mg/l
(3) Cobalt (Co)..........0.05 mg/l
(4) Molybdenum (Mo)..........1.0 mg/l
(5) Nickel (Ni)..........0.2 mg/l

[2-18-77, 1-29-82, 11-17-83, 3-3-86, 12-1-95; 20.6.2.3103 NMAC - Rn, 20 NMAC 6.2.III.3103, 1-15-01; A, 9-26-04]

[Note: For purposes of application of the amended numeric uranium standard to past and current water discharges (as of 9-26-04), the new standard will not become effective until June 1, 2007. For any new water discharges, the uranium standard is effective 9-26-04.]

PART 6
STATE HIGHWAY ACCESS MANAGEMENT REQUIREMENTS

18.31.6.1 ISSUING AGENCY:
New Mexico State Highway and Transportation Department, 1120 Cerrillos Road, Post Office Box 1149, Santa Fe, New Mexico 87504-1149.
[18.31.6.1 NMAC - Rp, 18 NMAC 31.6.1, 10/15/2001]

18.31.6.2 SCOPE:
NMSHTD Districts and Divisions, all other state agencies, local governments, land owners, developers, and general public.
[18.31.6.2 NMAC - Rp, 18 NMAC 31.6.2, 10/15/2001]

18.31.6.3 STATUTORY AUTHORITY:

A. **State Highway Commission:** The basic enabling legislation for the management of access on state highways is NMSA 1978, Section 67-11-2, which states: "The State Highway Commission is authorized and directed to do those things essential to plan, acquire by reasonable purchase or condemnation and construct a section or a part of a state or federally designated highway as a freeway or controlled-access highway or to make any existing state or federally designated highway a freeway or a controlled-access highway."

B. **State Highway and Transportation Department:** Pursuant to NMSA 1978, Section 67-3-6, the State Highway and Transportation Department shall exercise the power, authority, and duty granted to the State Highway Commission. Therefore, the Department may prescribe rules and regulations for providing access to state highways pursuant to NMSA 1978, Chapter 67. In addition, the following State Highway Commission policy and NMSHTD Administrative Directive supplement New Mexico State Statutes and shall be followed when determining the type and extent of access to be provided along state highways.

(1) State Highway Commission Policy CP 65, Interstate Access
(2) NMSHTD Administrative Directive AD 222, Highway Access Control

[18.31.6.3 NMAC - Rp, 18 NMAC 31.6.3, 10/15/2001]

18.31.6.4 DURATION:
Permanent.
[18.31.6.4 NMAC - Rp, 18 NMAC 31.6.4, 10/15/2001]

18.31.6.5 EFFECTIVE DATE:
October 15, 2001 unless a later date is cited in the history note at the end of a section.
[18.31.6.5 NMAC - Rp, 18 NMAC 31.6.5, 10/15/2001]

18.31.6.6 OBJECTIVE:

A. By 18.31.6 NMAC, the NMSHTD establishes access management requirements which

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will protect the functional integrity of the state highway system and the public and private investment in that system. Rule 18.31.6 NMAC, and its associated *State Access Management Manual* which is attached to and filed concurrently with this rule, provides procedures and standards to preserve and protect the public health, safety and welfare, to maintain smooth traffic flow, and to protect the functional level of state highways while considering state, regional, local, and private transportation needs and interests. The access management requirements also consider other Department regulations, policies and procedures related to highway rights-of-way such as drainage, archeology, hazardous materials and other environmental aspects.

B. Through the administration of 18.31.6 NMAC, it is the intent of the NMSHTD to work with property owners and local governments to provide reasonable access to the state highway system. However, the access rights of an owner of property abutting a state highway shall be held subordinate to the public's right and interest in a safe and efficient highway.

C. All owners of property abutting a public road have a right of reasonable access to the general system of streets and highways in the State, but not to a particular means of access. The right of access is subject to regulation for the purpose of protecting the health, safety and welfare of the traveling public.

D. Rule 18.31.6 NMAC addresses the design and location of driveways, medians, median openings, intersections, traffic signals, interchanges and other points of access to public highways under the jurisdiction of the New Mexico Highway Commission. It is based upon the authority granted to the State Highway and Transportation Department.

E. As of June 9, 1989, no person shall construct or modify any permanent or temporary access providing direct vehicular movement to or from any state highway from or to property in close proximity to or adjoining a state highway without an access permit issued by the State Highway and Transportation Department. Within those jurisdictions where the local governments and authorities have returned issuing authority to the Department, the Department has sole authority to issue state highway access permits. However, the Department will delegate the authority under 18.31.6 NMAC to other public agencies provided that these agencies minimally adopt the Rule and as the Department determines in its discretion as delegable.

F. Access permits shall be issued only when the permit application is found to be in compliance with 18.31.6 NMAC. The Department, or other issuing authority approved by the Department, is authorized to impose terms and conditions as necessary and convenient to meet the requirements of 18.31.6 NMAC. In no event shall an access permit be issued or authorized if it is detrimental to the public health, safety and welfare.

G. Direct access from a subdivision to a state highway shall be permitted only if the proposed access meets the purposes and requirements of 18.31.6 NMAC. All new subdivision of property shall provide access consistent with the requirements of 18.31.6 NMAC. The provisions of 18.31.6 NMAC shall not be deemed to deny reasonable access to the general street system. The issuance of any permit, agreement, plat, subdivision, plan or correspondence shall not abrogate or limit the regulatory powers of the Department or issuing authority in the protection of the public's health, safety and welfare.

[18.31.6.6 NMAC - Rp, 18 NMAC 31.6.6, 10/15/2001]

18.31.6.7 DEFINITIONS:

A. **Acceleration Lane**– A speed-change lane, including full-width auxiliary lane and tapered area, for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can safely merge with through traffic.

B. **Access**-- Any driveway or other point of access such as a street, road, or highway that connects to the general street system. Where two public roadways intersect, the secondary roadway shall be considered the access.

C. **Access Category**-- The definition by which access to a state highway is controlled according to the categories described in 18.31.6.10 NMAC.

D. **Access Control**-- The regulated limitation of access to and from a highway facility including full control of access, partial control of access, and driveway regulations.

E. ***Applicant***-- *The owner of property or the representative of an owner applying for an* access permit.

F. **Arterial Roadway**-- The primary function of an arterial roadway is to provide mobility for through traffic movements. Arterial roadways provide for land access as a secondary function.

G. **At-Grade Intersection**-- A crossing of two or more highway facilities at the same elevation where through traffic movements on one or more of the highways cross and where turning movements between the highway facilities may be allowed.

H. **Auxiliary Lane**-- An additional lane adjoining the traveled way which may be used for parking, speed change, turning, storage for turning vehicles, weaving, truck climbing, and other purposes supplementary to through traffic movement.

I. **Average Daily Traffic (ADT)**-- The average traffic volume per day, over a seven-day week, for a unique segment of roadway in both directions of travel on a two-way facility and in one direction of travel on a one-way facility.

J. **Average Weekday Traffic (AWDT)**-- The average traffic volume for a unique segment of roadway on a typical weekday (Monday through Friday) in both directions of travel on a two-way facility and in one direction of travel on a one-way facility.

K. **Average Weekend Traffic (AWET)**-- The average traffic volume for a unique segment of roadway over the weekend period (Saturday and Sunday) in both directions of travel on a two-way facility and in one direction of travel on a one-way facility.

L. **Business District**-- A business district occurs along a highway when within 300 feet along such highway there are buildings in use for business or industrial purposes (including but not limited to hotels, banks or office buildings, railroad stations and public buildings) which occupy at least fifty percent of the frontage on one side or fifty percent of the frontage collectively on both sides of the highway.

M. **CHDB**-- Consolidated Highway DataBase maintained by the New Mexico State Highway and Transportation Department.

N. **Capacity**-- The maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane or roadway under prevailing roadway, traffic, and control conditions.

O. **Change of Use**-- Occurs when a change in the use of the property including land, structures or facilities, or an expansion of the size of the structures or facilities, is expected to result in an increase in the trip generation of the property greater than 25 percent (either peak hour or daily) and greater than 100 vehicles per day more than the existing use.

P. **Channelized Intersection**-- An "at grade" intersection with painted islands, raised islands, or other devices for directing traffic along definite paths.

Q. **Collector Street**-- Collector streets connect developed areas with the arterial street system, balancing the need to provide traffic movement with the need to provide property access.

R. **Commission**-- The New Mexico State Highway Commission.

S. **Control of Access**-- The condition in which the right of owners or occupants of land abutting or adjacent to a roadway is controlled by public authority.

T. **Controlled-Access Highway**-- Includes highways, streets or roadways to which owners or occupants of abutting lands, and other persons, have no legal right of access except as determined by the public authority having jurisdiction over the highway, street or roadway.

U. **Corner Clearance**-- At an intersecting street or highway, the dimension measured along the edge of the traveled way between the centerline of the intersecting street and the centerlines of the first adjacent access points on the approach and departure sides of the intersection.

V. **Cross Street**-- The lower function roadway that crosses a higher function facility, also referred to as Minor Street.

W. **Curb Cut**-- An opening along a state highway with raised curb or curb-and-gutter to provide for driveway access using drivepad construction. Also referred to as Driveway Cut.

X. **Curb Return**-- The access radius for an intersection or driveway opening, also referred to as Radius Return.

Y. **Curb Return Construction**-- As applied to a driveway opening, means that proper access radii are used in the design and construction of an access facility.

Z. **Deceleration Lane**-- A speed-change lane, including full-width auxiliary lane and tapered areas, for the purpose of enabling a vehicle to slow to a safe turning speed when exiting a roadway.

AA. **Department**-- The New Mexico State Highway and Transportation Department.

AB. **Design Vehicle**-- A selected motor vehicle with the weight, dimensions, and operating characteristics used to establish highway design controls.

AC. **Developer**-- A person or persons representing a proposed land development project.

AD. **Divided Highway**-- A highway with separated roadways for traffic traveling in opposite directions. Separation may be provided by depressed dividing strips, raised medians, traffic islands, other physical separations, standard pavement markings, or other traffic control devices.

AE. **Drivepad Construction**-- As applied to a driveway or curb cut, means that access radii are not used in the design and construction of an access facility.

AF. **Driveway**-- For the purposes of NMSHTD access management requirements, a driveway is a public or private access along a state highway serving a limited area where traffic signal control is not required. Excludes public streets, roads, highways, and other signalized intersections.

AG. **Driveway Angle**-- The angle of 90 degrees or less between the driveway centerline and the edge of the traveled way.

AH. **Driveway Cut**-- An opening along a state highway with raised curb or curb-and-gutter to provide for driveway access using drivepad construction. Also referred to as Curb Cut.

AI. **Driveway Throat Width**-- The narrowest width of a driveway measured parallel with the edge of the traveled way exclusive of radii, ramps or tapers.

AJ. **Edge Clearance**-- The distance measured along the edge of the traveled way between the frontage property line and the point of tangency of the nearest radius return for an access.

AK. **Egress**-- To exit an abutting property or intersecting roadway to gain access to a state highway.

AL. **Freeway**-- A multi-lane divided highway having a minimum of two lanes in each travel direction, with access provided by grade-separated interchanges.

AM. **Frontage**-- The distance along the highway right-of-way line of a single property tract or roadside development area between the limits of the property.

AN. **Frontage Property Line**-- A line, perpendicular to the highway centerline, at each end of the frontage, extending from the right-of-way line to the edge of traveled way.

AO. **Full Control of Access**-- That part of access control where preference is given to through traffic by providing access connections only with selected public roads, and by prohibiting at-grade crossings and direct private driveway connections. Access control is accomplished by legally obtaining right-of-way from the abutting property owners or by the use of frontage roads or other means to provide access to abutting properties.

AP. **Functional Classification**-- The grouping of highways by the character of service they provide to through traffic movements (mobility) versus access to abutting properties (land accessibility).

AQ. **General-Purpose Lanes**-- The continuous through lanes on a highway, excluding auxiliary lanes. Sometimes referred to as mainline lanes.

AR. **General Street System**-- The interconnecting network of city streets, county roads, and state highways.

AS. **Grade Separation**-- A crossing of two transportation facilities, such as two roadways or a roadway and a railroad, at different elevations where access is not provided from either facility at their intersection.

AT. **Grade or Gradient**-- The rate (or percent) of change in slope. For highway facilities, it is measured along the centerline of the roadway or access facility.

AU. **Highway**-- The entire width between the right-of-way lines of publicly maintained traveled way when any part thereof is open to the public for purposes of vehicular travel, or the entire width of any traveled way declared to be a public highway by law. It may include bridges, culverts, sluices, drains, ditches, waterways, embankments, walls, trees, shrubs and fences.

AV. **Highway Improvement Project**-- Includes any project to improve a roadway segment or intersection facility to protect and maintain the general health, safety and welfare of the traveling public, typically conducted by the public entity having jurisdiction over the facility being improved. Highway improvement projects are generally included in the public entity's transportation improvement program, whether the program is local, regional or statewide.

AW. **Horizontal Alignment**-- The combination of curved and tangent sections of a highway in the horizontal plane.

AX. **Ingress**-- To leave the highway and enter into an abutting property or intersecting roadway.

AY. **Intersection**-- Public street or other access serving a large area or a major traffic generator(s) where traffic signal control may be provided.

AZ. **Interstate Highway**-- Represents the highest functional classification of a roadway in a highway network. Interstates are multi-lane divided highways having a minimum of two lanes in each travel direction, with access provided by grade-separated interchanges.

BA. **km/h**-- A rate of speed measured in kilometers traveled per hour.

BB. **Land Development Project**-- Includes any project to develop or redevelop private or public property adjacent or in close proximity to a state highway where direct or indirect access to the property is required from the state highway. Land development projects may be conducted by private and/or public entities.

BC. **Lane**-- The portion of a roadway for the movement of a single line of vehicles, not including the gutter or the shoulder of the roadway.

BD. **Level of Service (LOS)**-- A qualitative measure describing traffic operational conditions within a traffic stream based on factors such as speed, travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. Level of service designations range from A (best) to F (worse).

BE. **Local Governments and Authorities**-- Every county, municipal, and other local board or body having authority to enact laws relating to traffic under the constitution and laws of the State of New Mexico.

BF. **Local Road**-- Local roads primarily provide direct access to abutting land and to roads of higher functional classification. Mobility is discouraged, especially in urban areas.

BG. **May**-- A permissive condition where the condition is suggested but not mandatory.

BH. **MUTCD**-- Manual on Uniform Traffic Control Devices for Streets and Highways, latest edition.

BI. **Median**-- That portion of a divided highway separating traffic traveling in opposite directions.

BJ. **Minor Street**-- The lower function roadway that crosses a higher function facility, also referred to as Cross Street.

BK. **mph**-- A rate of speed measured in miles traveled per hour.

BL. **NMSHTD**-- The New Mexico State Highway and Transportation Department.

BM. **Nominal Control of Access**-- That part of access control that may be applied when full or partial control of access has not been obtained by a highway authority. A means of access control that is consistent with the functional classification of a state highway facility, and that is sufficient to maintain a safe and efficient transportation system.

BN. **Non-Access Controlled Highway**-- Includes state highways where roadside access is permitted and access control has not been established by legally obtaining right-of-way from the abutting property owners or by the use of frontage roads or other means to provide access to abutting properties.

BO. **Non-Traversable Median**-- A median which, by its design, physically discourages or prevents vehicles from crossing it except at designated openings which are designed for turning or crossing movements.

BP. **Partial Control of Access**-- That part of access control where preference is given to through traffic to a degree that some at-grade crossings may be permitted. Access control is accomplished by legally obtaining right-of-way from the abutting property owners or by the use of frontage roads or other means to provide access to abutting properties.

BQ. **Permittee**-- The individual(s) responsible for fulfilling the terms and conditions of the access permit as imposed by the Department.

BR. **Property Owner**-- The person or persons holding the recorded title to property abutting a state highway, and other persons holding a recorded interest in such property, that includes a right to reasonable access from the state highway system.

BS. **Radius Return**-- The access radius for an intersection or driveway opening, also referred to as Curb Return.

BT. **Recovery Area**-- An unobstructed area provided beyond the edge of a traveled way for the recovery of errant vehicles.

BU. **Right-In/Right-Out Driveway (RI/RO)**-- A driveway located along a roadway prohibiting left-turn access into or out of the driveway.

BV. **Setback**-- The lateral distance between the highway right-of-way line and any development structure, obstacle or parking area along the highway roadside.

BW. **Shall**-- A mandatory condition where the requirements must be met.

BX. **Should**-- An advisory condition where the condition is recommended but not mandatory.

BY. **Sight Distance**-- The length of roadway visible to the driver of a vehicle, as further defined in the AASHTO document, *A Policy on Geometric Design of Highways and Streets*, latest edition.

BZ. **Signal Progression**-- The timing of consecutive signalized intersections to provide for the progressive movement of traffic at a planned rate of speed.

CA. **Speed-Change Lane**-- A separate lane for the purpose of enabling a vehicle entering or leaving a roadway to increase or decrease its speed to a rate at which it can more safely merge into or exit from through traffic.

CB. **State Highway**-- Any public highway that has been designated as a state highway by either the New Mexico State Legislature or the State Highway Commission.

CC. **Stopping Sight Distance**-- The distance required by a driver of a vehicle to bring the vehicle to a stop after an object on the roadway becomes visible.

CD. ***Storage Lane Length***-- *The length provided within a deceleration lane for the storage* of queued vehicles, typically based on the vehicle queue expected during peak travel periods.

CE. **Subdivide**-- To divide land into two or more smaller lots, tracts or parcels of land.

CF. **Subdivision**-- A tract of land which has been subdivided in accordance with the laws of the state usually with appropriate streets, dedications and other facilities for the development or sale of industrial, commercial or residential land.

CG. **Traveled Way**-- That portion of a roadway containing the travel lanes and speed-change lanes, exclusive of pavement provided for shoulders.

CH. **Traversable Median**-- A median which, by its design, does not physically discourage or prevent vehicles from entering upon or crossing it.

CI. **Trip**-- A one way vehicle movement from one location to another.

CJ. **Trip Assignment**-- Refers to the addition of trips generated by a proposed development to a transportation network. Involves the specific routing of traffic on the street system.

CK. **Trip Distribution**-- Refers to the geographic origin or destination of trips related to a project. Involves the general allocation of trips generated by a development over the transportation network.

CL. **Trip Generation**-- An estimate of the number of trips expected to be generated by specific type of land use.

CM. **Undivided Roadway**-- A highway without physical separation between traffic traveling in opposite directions.

CN. **Vertical Alignment**-- The vertical profile of a highway, intersection approach or driveway approach, typically measured along its centerline.
[18.31.6.7 NMAC - Rp, 18 NMAC 31.6.7, 10/15/2001]

18.31.6.8 REFERENCES:
The reference documents listed in 18.31.6.9 NMAC are supplementary and should be used when additional detail is required to address issues that arise during the access permitting and design process. The most recent edition of each technical reference shall be used.
[18.31.6.8 NMAC - Rp, 18 NMAC 31.6.8, 10/15/2001]

18.31.6.9 REFERENCE LIST:

A. New Mexico State Statutes and Traffic Laws, as amended.

B. The current editions, as amended, of the following NMSHTD manuals, standards, and policies:

(1) State Access Management Manual
(2) Standard Specifications for Road and Bridge Construction
(3) Highway Commission Policies
(4) Standard Drawing Serials and Designated Drawings
(5) Drainage Manual, Volume I - Hydrology, Volume II - Sedimentation and Erosion, and Drainage Design Criteria (Administrative Memorandum 221), latest editions
(6) New Mexico State Traffic Monitoring Standards
(7) Railroads and Utilities Manual
(8) Materials Manual
(9) *Construction Manual*
(10) Location Study Procedures, A Guidebook for Alignment and Corridor Studies

C. A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, latest edition.

D. Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation, Federal Highway Administration, latest edition.

E. Highway Capacity Manual, Transportation Research Board, National Research Council, latest edition.

F. Trip Generation, Institute of Transportation Engineers, latest edition.

G. Roadside Design Guide, American Association of State Highway and Transportation *Officials, latest edition.*

H. Manual of Transportation Engineering Studies, Institute of Transportation Engineers, 1994.

I. A Guide for Erecting Mailboxes on Highways, American Association of State Highway and Transportation Officials, 1994.

J. Americans with Disabilities Act, Accessibility Guidelines for Buildings and Facilities (ADAAG), Architectural and Transportation Barriers Compliance Board, as amended; Federal Register, 36 CFR Part 1191, June 20, 1994.

K. Traffic Engineering Handbook, Fourth Edition, Institute of Transportation Engineers, 1992.

L. *Access Management Guidelines for Activity Centers, NCHRP 348, 1992.*

M. Manual of Traffic Signal Design, Second Edition, Institute of Transportation Engineers, 1991.

N. Traffic Access and Impact Studies for Site Development, Institute of Transportation Engineers, 1991.

O. Guide for the Development of Bicycle Facilities, American Association of State Highway and Transportation Officials, 3rd Edition, 1999.

P. Transportation and Land Development, Institute of Transportation Engineers, 1988.

Q. An Informational Guide for Roadway Lighting, American Association of State Highway and Transportation Officials, 1984.

R. Web Sites *(note: web addresses may change without notice)*

(1) New Mexico State Highway and Transportation Department: www.nmshtd.state.nm.us
(2) Federal Highway Administration: www.fhwa.dot.gov
(3) Institute of Transportation Engineers: www.ite.org
(4) American Association of State Highway and Transportation Officials:

www.transportation.org

(5) Transportation Research Board: www.nas.edu/trb

(6) National Cooperative Highway Research Program: *www4.nationalacademies.org/trb/crp.nsf*

[18.31.6.9 NMAC - Rp, 18 NMAC 31.6.9, 10/15/2001]

18.31.6.10 ACCESS CATEGORIZATION SYSTEM:
The regulation and management of vehicular access to and from the New Mexico state highway system shall be defined by an access categorization system. The access categorization system for state highways is described in Section 10 of the *State Access Management Manual*. The access categorization system shall be based on the Functional Classified System for New Mexico roadways, which consists of interstates and freeways (INTS), principal arterials (PRAR), minor arterials (MNAR), major collectors (MJCL), minor collectors (MNCL), collectors (COLL), local roads (LOC), and other special road types. The functional classified system shall be further defined as urban and rural routes based on the location of a highway with respect to population centers. The current classification of a highway shall be obtained from the Department and shall be used to determine the access category applicable to the highway under consideration. Access requirements for each access category are described in the *State Access Management Manual*.
[18.31.6.10 NMAC - Rp, 18 NMAC 31.6.11.1 through 18 NMAC 31.6.11.3, 10/15/2001]

18.31.6.11 ACCESS MANAGEMENT PLANS:
The Department may develop an access management plan for a designated portion of state highway. An access management plan provides the Department, and local authority, with a comprehensive roadway access design plan for a designated state highway segment or corridor for the purpose of bringing that portion of highway into conformance with its access category and its functional needs to the extent feasible given existing conditions. Access management plans should be developed as described in Section 11 of the *State Access Management Manual*.

A. Access management plans for state highways are developed by the Department in cooperation with the appropriate local authorities through a memorandum of understanding or a joint powers agreement. Access management plans shall be adopted by the Department to become effective. The adoption of a plan shall be in the form of a formal written agreement prepared in accordance with 18.31.6.19 NMAC, Access Control Review Procedures. When applicable, concurrence of the local authority should also be obtained in written form.

B. After an access management plan is adopted, modifications to the plan shall require Department approval. Where an access management plan is in effect, all action taken in regard to access shall be in conformance with the plan and 18.31.6 NMAC unless the Department approves exceptions to the plan in writing.

[18.31.6.11 NMAC - N, 10/15/2001]

18.31.6.12 INTERCHANGE ACCESS MANAGEMENT PLANS:
An interchange access management plan shall be required for any new interchange or significant modification to an existing interchange. The interchange access management plan shall satisfy the requirements of 18.31.6.19 NMAC, Access Control Review Procedures, and applicable

Highway Commission policies and Department administrative directives. The interchange and the management plan shall receive the approval of the Deputy Secretary for Planning and Design. If located on a national or interstate highway facility, approval shall also be obtained from the Federal Highway Administration. Section 12 of the *State Access Management Manual* should be used to guide the development of interchange access management plans.
[18.31.6.12 NMAC - N, 10/15/2001]

18.31.6.13 ACCESS CATEGORY STANDARDS:

A. Purpose: Whereas the requirements for access requests along state highways are described in multiple sections of 18.31.6 NMAC, summary information for each access category is provided in Section 13 of the *State Access Management Manual* to assist users in locating and determining the requirements for a proposed access along a state highway. Practitioners shall reference specific sections of 18.31.6 NMAC when determining applicable requirements for their access request. The summary information contained in Section 13 of the manual is provided solely to ease use of the access management manual, with the exception below regarding interstate highways.

B. Interstate Highways: The design of interstate highway facilities, requests for modifications to existing interstate access points, and new interstate access proposals shall satisfy the requirements of all pertinent sections of the Code of Federal Regulations (CFR) and all interstate highway policies adopted by the Federal Highway Administration. All decisions regarding interstate highway facilities shall require the approval of the Federal Highway Administration and the NMSHTD.
[18.31.6.13 NMAC - N, 10/15/2001]

18.31.6.14 PERMITTING PROCESS:

A. Purpose: This section describes the application procedures for submitting an access permit request to the Department, and the administrative procedures used by the Department to approve or deny access permit requests on state highways.

B. Types of Access: Following is a list of the types of access that may occur along the state highway system. Refer to Section 14 of the *State Access Management Manual* for a description of each access type.

(1) Existing Lawful Access, Modification or Transfer
(2) New Private Access (Individual Use)
(3) New Subdivision Access
(4) New Public Access
(5) New Commercial Access
(6) Temporary Construction Access
(7) Temporary Access
(8) Emergency Access
(9) Field Access
(10) Access Breaks in Established Access Control Lines
(11) Illegal Access

C. Access Permit Applications: Applications for access permits shall be made by the property owner; the property owner's authorized representative; or, the local governmental agency requesting access from a state highway. Applications are required for all new access types, for modification or transfer of existing lawful access permits, and for upgrading an existing illegal access to a lawful access.

(1) Changes in Property Use: Where additional traffic is projected due to expansion or redevelopment of a property, the property owner shall contact the Department to determine if a new permit application and modifications to existing access points will be required. If the Department determines that the increased traffic generated by the property does not require modifications to the existing permitted access, according to the procedures of 18.31.6.16 NMAC, a new permit application will not be required. Failure to contact the Department to determine the need for access modifications or to apply for such modifications prior to initiation of property improvements, land use changes or traffic flow alterations actions, may result in notification to the property owner of intent to revoke or modify the existing permit and closure of the access to the property. (Also refer to Subsection O of 18.31.6.7 NMAC.)

(2) Permit Application Form: All applications shall be made on the approved NMSHTD permit application form, "Application for Permit to Construct Driveway or Median Opening on Public Right-of-Way."

(3) NMSHTD District Offices: Persons wishing to submit an access permit application form should contact the appropriate NMSHTD District Office to obtain application forms. District offices are located in Deming, Roswell, Albuquerque, Las Vegas, Santa Fe, and Milan. The application form can also be found in the appendix of the *State Access Management Manual,* and on the NMSHTD Access Management web site.

D. Application Submittal Requirements:

(1) Completed access permit forms shall be submitted to the appropriate District office with proof of ownership of the property to which access is requested. A plan or sketch of the property shall be attached to the permit application showing the length of the property frontage, the distance from the edge of the traveled roadway to the property line, edge clearances, corner clearances, the distance from the referenced mile marker to the centerline of the proposed driveway(s), and the location of any access drives along the state highway across from the proposed site. A traffic engineering evaluation shall be conducted for all access permit requests according to the requirements of 18.31.6.15 NMAC and 18.31.6.16 NMAC, with an exception. The traffic engineering evaluation may be waived for individual use access requests (see Subsection E, Paragraph 1 of 18.31.6.14 NMAC). In such cases, the Department may conduct the evaluation required to determine if an individual use access will be permitted or denied. A construction traffic control plan shall also be submitted with the application for review and approval by the District Traffic Engineer. The Department may require additional information relative to the evaluation of a permit application as further described in Section 14 of the *State Access Management Manual*.

(2) A permit application may be refused by the Department when necessary and relevant information is missing, or when there is no written evidence of the ownership of the property surface rights provided in the application. If the application is refused, the Department shall notify the applicant within ten (10) working days of receipt of the application and shall indicate the reason or reasons for refusal. The Department review period begins with the acceptance of an application.

(3) Each permittee understands and agrees as a condition of issuance of any permit, that if the Department determines that any violation has or may result in the creation or existence of any safety or traffic hazard, the Department may immediately take such action as the Department deems necessary to correct, eliminate or mitigate such hazard, without the need for the completion of any review process.

E. Access Permit Requests from Private Entities:

(1) Individual Use: Requests for a new private access shall be made on the NMSHTD access permit application. Application requirements for individual use permits shall include a platted survey of

the property, proof of ownership of the property, and details regarding the location of the proposed access and the proposed development. A traffic engineering evaluation typically shall not be required. The Department may conduct the evaluation required to determine if an individual use access will be permitted or denied.

(2) Subdivisions and Commercial Developments: Requests for new subdivision access, new commercial access or for modification to an existing lawful access for other than individual use shall be made on the access permit application. The applicant shall be required to satisfy all pertinent requirements of *18.31.6* NMAC.

F. Access Permit Requests from Governmental Entities:

(1) Local Governments: Requests by local governmental agencies for new access or for the reconstruction of existing access to the state highway shall be administered by the Department. The local governmental agency shall be considered the applicant. The Department shall work with local governmental agencies realizing that the access will serve multiple property owners. Access to subdivisions and other developments shall not be considered public access until the access is constructed and accepted as a local public roadway.

(a) Local governmental agencies shall provide notice of all developments that will directly or indirectly impact the state highway, and shall request Department participation in the *administration of an access permit if it is determined by the Department that an access facility will* directly or indirectly impact the operation and function of a state highway. The local governmental agencies may also require subdividers to provide additional notice of all proposed developments that will directly or indirectly impact the state highway.

(b) Where a private development accessing the roadway of an appropriate local authority necessitates access improvements where the local roadway connects to a state highway, the permittee shall be the local jurisdiction.

(c) *Local governmental agencies may be required to submit a traffic engineering* evaluation with a permit application. The traffic engineering evaluation requirement shall be determined according to the procedures described in 18.31.6.15 NMAC and 18.31.6.16 NMAC. Local governmental agencies may require developers to assist in preparing and providing this information for submission to the State.

(2) Federal Government: Requests for access from a state highway by the General Services Administration (GSA), United States Postal Service (USPS), Department of Defense (DOD), Department of Energy (DOE), or other divisions of the federal government shall be administered by the NMSHTD in cooperation with the pertinent division of the federal government. The access location, spacing and design standards described in 18.31.6.18 NMAC and Section 18 of the *State Access Management Manual* should be followed for such requests.

(3) Sovereign Nations: Access requests on state highway segments that traverse sovereign nation lands shall be administered by the Department in cooperation with the pertinent sovereign nation: The access location, spacing and design standards described in 18.31.6.18 NMAC and Section 18 of the *State Access Management Manual* should be followed for such requests.

G. Administrative Review Process:

(1) An administrative review period begins with the acceptance of a permit application by the appropriate District Engineer or the District Engineer's designee.

(2) Upon acceptance of the application permit and supplemental information, the Department shall use 18.31.6 NMAC, the *State Access Management Manual* and any other applicable state statutes for evaluating and acting on the application. Access requests that break existing access control lines or that are requested on a controlled-access facility shall be acted on by the Access Control

Review Committee according to the procedures in 18.31.6.19 NMAC. The application will normally be processed within forty-five (45) days. The review period may be extended by the Department when action is required by the Access Control Review Committee. Transmittal of a completed permit, approved by the District Engineer, or transmittal of a denied application constitutes action on the permit application.

(3) If the Department approves an application permit, the permit shall be prepared and transmitted to the applicant along with any additional terms and conditions established by the Department. The owner noted on the permit, normally the surface right owner, will become the permittee. If the permittee does not agree to all terms and conditions of the permit, the permit shall not be issued.

(4) In accepting the permit, the permittee agrees to all terms and conditions of the permit. Should the permittee or applicant choose to appeal a denied application, or the terms and conditions of a permit, the appeal shall be filed within sixty (60) days of the date the denial notice or the approved permit is transmitted.

(5) The issue date of the permit is the date the Department representative signs the permit.

(6) The granting of an access permit conveys no rights, title or interest in state highway rights-of-way to the permit holder or property served. A permit for direct access to a state highway does not entitle the permit holder to control or have any rights or interests in any portion of the design, specifications or operation of the highway or roadway, including those portions of the highway built pursuant to the terms and conditions of the permit.

(7) If the Department denies an application, the Department shall provide the applicant a copy of the application marked "denied" along with any attachments and a written explanation for the decision. The Department or the applicant may request a meeting with the Department to discuss reasons for denial.

(8) Denial of an application request for physical modifications to an existing lawful access does not constitute revoking access authorization for the existing access.

(9) Requests for variance from the standards of 18.31.6 NMAC may be submitted to the District Engineer and shall be considered an attachment to the permit application. The review of variance requests shall be in accordance with Subsection I of 18.31.6.14 NMAC. Variance procedures may be used when the standards established by 18.31.6 NMAC are not entirely applicable to the proposed request for access.

(10) If, at the sole discretion of the Department, it is determined that a permittee is in violation of 18.31.6 NMAC or any conditions of a permit, the Department may revoke the permit. The revocations process shall be as described in Subsection N of 18.31.6.14 NMAC.

H. **Permit Fees:** The Department may establish a reasonable schedule of fees for access permits issued pursuant to 18.31.6 NMAC. It is the responsibility of the applicant to determine if any local governmental fees are applicable.

I. **Appeals and Variance Procedures:**

(1) If the permittee or applicant objects to the denial of a permit application by the Department or objects to any of the terms or conditions of the permit placed therein by the Department, a written appeal shall be filed with the appropriate District Engineer within sixty (60) days of the transmittal of notice of denial or transmittal of the approved permit. The request shall include reasons for the appeal and may include recommendations by the permittee or applicant.

(2) The District Engineer, or the District Engineer's designee, will submit a written request for review to the NMSHTD Traffic Technical Support engineer along with the permit application, the written appeal, and all supporting information. The Traffic Technical Support engineer will review the request and the appeal and offer an opinion to the District Engineer regarding the merits of the appeal. It is the intent of this process that an agreement is reached between the Traffic Technical Support engineer and the District Engineer. If, however, agreement cannot be reached, a formal meeting shall be scheduled with the Deputy Secretary for Planning and Design to hear the appeal. This meeting should involve the Applicant, the Traffic Technical Support engineer, and the District Engineer or designee. The Traffic Technical Support engineer shall provide a summary presentation of the facts and issues of dispute along with a discussion of the consequences, safety assessment, risks and value associated with the permit application. If applicable, the appeal should include a report from the Applicant's engineer. The Deputy Secretary for Planning and Design shall make the final decision. Final decisions that are exceptions to existing standards and regulations may be sent to the Federal Highway Administration for approval if their involvement is deemed appropriate by the Deputy Secretary for Planning and Design. At this final decision point, no other Department employee will be authorized to approve the permit.

(3) If an applicant wishes to seek a variance from the standards of 18.31.6 NMAC, a written request shall be submitted as an attachment to the permit application form. The request for variance should include specific and documented reasons.

(4) Review of the request for variance shall follow the procedure described in Subsection I, Paragraph 2 of 18.31.6.14 NMAC.

J. Construction of Access by Owner:

(1) An approved access permit shall be deemed expired and null and void if the access is not under construction within six (6) months from the date of issue unless otherwise noted and approved by the Department in writing. When the permittee is unable to commence construction within six (6) months after the permit issue date, a six-month extension may be requested from the District Engineer. Any request for an extension shall be in writing and submitted to the District Engineer before the permit expires. Denial of an extension may occur when the District Engineer ascertains and documents that unforeseen and significant changes in highway traffic operations, proposed access operation, or statutes and regulations that were not considered in the issuance of the permit have occurred. Any person wishing to reestablish an access permit that has expired shall be required to submit a new permit application and comply with all related requirements, as specified by the District Traffic Engineer.

(2) The permittee shall notify the District Engineer, or the District Engineer's designee, of pending access construction at least three (3) working days prior to any construction in state highway right-of-way. Construction of the access shall not proceed until both the access permit and a construction traffic control plan are approved. The access shall be constructed and completed in an expeditious and safe manner and shall be finished within forty-five (45) days of initiation of construction within the highway right-of-way. Failure by the permittee to complete construction in the 45-day period shall be sufficient cause for the Department to initiate action to suspend or revoke the permit or to close the access.

(3) The construction of the access and its appurtenances as required by the terms and conditions of the permit shall be completed at the expense of the permittee, unless other arrangements are made with the District Engineer. The permittee should arrange for access construction to be completed by qualified contractors. Construction shall meet all Department specifications and shall be subject to inspection by the Department.

(4) Property required for highway access improvements shall be dedicated, without cost, to the Department. All rights, titles and interests of dedicated property shall be conveyed to the Department. All current title policies shall be disclosed and be acceptable to the Department. The owner shall certify that the property is clean of contamination or indemnify the Department from any remediation responsibilities prior to conveyance. The Department may refuse to accept any property containing or suspected of containing hazardous substances, toxic wastes or other contaminants until such substances *are removed and/or the property is certified clean by the appropriate governmental entity.* The access is not considered complete until property is conveyed.

(5) All materials used in the construction of the access within the highway right-of-way or on permanent easements become public property. Any materials removed from the highway right-of-way shall be disposed of as directed by the Department. All fencing, guard rail, traffic control devices and other equipment and materials removed in the course of access construction shall be given to the Department unless otherwise instructed by the permit or the Department inspector.

(6) The Department, at its discretion, may complete the installation of permanent traffic control devices. The permittee shall pay for direct costs and labor provided by the Department for the installation and relocation of all traffic control devices within public right-of-way directly related to the use or construction of the permitted access. Failure of the permittee to pay within a reasonable period may be considered grounds for permit suspension, which may lead to revocation and access removal.

(7) Where access construction requires the reconstruction of the existing state highway, the Department may require the contractor or permittee to post a bond to ensure completion of the work.

(8) The permittee shall provide adequate advance warning at all times during access construction according to the construction traffic control plan accompanying the approved access permit. The traffic control plan shall conform with the *Manual of Uniform Traffic Control Devices for Streets and Highways* (MUTCD). Construction traffic control may include the use of signs, flashers, barricades, and flaggers.

(9) The Department may restrict work on or immediately adjacent to the highway, control *lane closure periods, and require pre-approval of all aspects of construction phasing where access* construction will affect traffic operations, roadway capacity and/or safety. Every effort shall be made to minimize the closure periods of any travel lanes. Work in the right-of-way may not be allowed on holidays, at night, during peak traffic hours, or during adverse weather conditions without written permission from the District. Work hours shall be approved by the District Traffic Engineer.

(10) A utility permit shall be obtained for any utility work within highway right-of-way. Where necessary to remove, relocate, or repair a traffic control device or public or private utilities for access construction, the relocation, removal or repair shall be accomplished by the permittee without cost to the Department and at the direction of the Department or utility company. Any damage to the state highway or other public right-of-way beyond that which is allowed in the permit shall be repaired immediately. The permittee is responsible for the repair of any utility damaged in the course of access construction, reconstruction, or repair.

(11) Prior to use of the access, the permittee is required to complete the construction according to the terms and conditions of the access permit. Failure by the permittee to abide by all permit terms and conditions shall be sufficient cause for the Department to initiate action to suspend or revoke the permit or to close the access. If the permittee wishes to use the access prior to completion, arrangements shall be approved by the Department and included in the permit. The Department may order a halt to *any unauthorized use of the access pursuant to statutory and regulatory powers.* Reconstruction or improvement of the access may be required when the permittee has failed to meet required specifications of design or materials.

(12) If any construction element fails within two years due to improper construction or material specifications, the permittee shall be responsible for all repairs. Failure to make such repairs may result in suspension of the permit and closure of the access.

K. Inspection of Access:

(1) The permittee should employ a construction inspector to ensure that the conditions of the access permit are met. The District Engineer, or the District Engineer's designee, may inspect the access during construction and upon completion of the access to ensure that all terms and conditions of the permit are met. Inspectors are authorized to enforce the conditions of the permit during construction and to halt any activities within state right-of-way that (1) do not comply with the provisions of the permit, (2) conflict with concurrent highway construction or maintenance work, (3) endanger highway property, natural or cultural resources protected by law, or (4) endanger the health and safety of workers or the public.

(2) The permittee shall ensure that a copy of the permit is available for review at the construction site at all times. The permit may require the contractor to notify the District representative noted on the permit at any specified phases in construction to allow a field inspector to inspect various aspects of construction such as concrete forms, subbase, base course compaction, and materials specifications. Minor changes and additions may be ordered by the Department field inspector to meet unanticipated site conditions. The Department may require the permittee to hire a New Mexico registered professional civil engineer to affirm to the best of the engineer's knowledge that the construction is in compliance with the permit and Department specifications. The Department may require testing of materials. When required, test results shall be provided to the Department.

L. Maintenance of Access: The permittee, his or her heirs, successors-in-interest, assigns, and occupants of the property serviced by the access shall be responsible for meeting the terms and conditions of the permit, the repair and maintenance of the access beyond the edge of the roadway including any cattle guard and gate, and the removal of snow or ice upon the access even though deposited on the access in the course of Department snow removal operations. Any significant repairs, such as culvert replacement, resurfacing, or changes in design or specifications, require authorization from the Department. The Department shall maintain the roadway including auxiliary lanes and shoulders, except in those cases where the access installation has failed due to improper access construction and/or failure to follow permit requirements and specifications (see Subsection J, Paragraph 12 of 18.31.6.14 NMAC). In this case, the permittee shall be responsible for such repair.

(1) Within unincorporated areas, the Department shall keep access culverts clean as part of maintenance of the highway drainage system. However, the permittee shall be responsible for the repair and replacement of any access-related culverts within the right-of-way.

(2) Within incorporated areas, drainage responsibilities for municipalities shall be determined by statute and local ordinance.

M. Indemnification: The Department and its duly appointed agents and employees shall be held harmless against any action for personal injury or property damage sustained by reason of the exercise of the permit.

N. Revocations:

(1) Where a change in property use occurs or a property's basic vehicular usage changes, so as to impact the highway, and the existing access points do not comply with 18.31.6 NMAC, the owner shall apply for a new access permit and reconstruct the driveways to comply with the Rule.

(2) If, at the sole discretion of the Department, it is determined that a permittee is in violation of 18.31.6 NMAC or any conditions of the access permit, the Department, acting through the District Engineer, or the District Engineer's designee, for the District where the driveways are located, shall inform the permittee in writing of the violations and allow the permittee thirty (30) days to correct the violations.

(3) If, after thirty (30) days, the violations are not corrected, the District Engineer, or the District Engineer's designee, may revoke the permit.

(4) The permittee may request a hearing on the revocation of the permit by giving written notice to the District office within ten (10) days of the notice of the revocation.

(5) The requested hearing shall be held no later than thirty (30) days after receipt of the notice of hearing. The Department's representatives shall be the District Engineer and the District Traffic Engineer, or their designees. After the hearing, the District Engineer, or the District Engineer's designee, shall issue a written decision.

(6) The permittee may appeal that decision to the Deputy Secretary for Planning and Design at the General Office in Santa Fe by giving written notice of a request for an appeal to the District Office within ten (10) days of the date of the District's written decision.

(7) The Deputy Secretary for Planning and Design, or the Deputy's designee, shall hear the appeal within thirty (30) days of receipt of the request for an appeal.

(8) The decision of the Deputy Secretary, or the Deputy's designee, shall be final and this decision completes the administrative review process.

(9) After the review process, or at any stage if the conditions set out in Subsection N, Paragraph 10 of 18.31.6.14 NMAC occurs, the District Engineer, or the District Engineer's designee, may take whatever action is appropriate including, but not limited to, physically closing the driveway with barriers or signing, and the Department may refuse to issue future permits to the permittee until the violations are corrected.

(10) Each permittee understands and agrees as a condition of issuance of any permit, that if the Department determines that any violation has or may result in the creation or existence of any safety or traffic hazard, the Department may immediately take such action as the Department deems necessary to correct, eliminate or mitigate such hazard, without the need for the completion of any review process.
[18.31.6.14 NMAC - Rp, 18 NMAC 31.6.10, 10/15/2001]

18.31.6.15 TRAFFIC ENGINEERING EVALUATION:

A. General: A traffic engineering evaluation shall be required for all proposed access points that are requested along the state highway system, to be submitted with the Access Permit Application (see Subsection D, Paragraph 1 of 18.31.6.14 NMAC). The extent of the traffic engineering evaluation is directly related the scope of the highway improvement under consideration, or to the size and type of land use for which access is requested. In this section, operational performance standards, traffic data requirements and traffic signal considerations are described. Additional information regarding traffic engineering evaluation requisites are provided in Section 15 of the *State Access Management Manual.* The specific traffic study process that shall be followed to address the traffic engineering evaluation requirement for a land development project are described in 18.31.6.16 NMAC. The criteria that shall be used to determine when speed-change lanes are required or should be considered at existing or proposed access points along the state highway system are defined in 18.31.6.17 NMAC. Design standards applicable to the traffic engineering evaluation are provided in 18.31.6.18 NMAC and are further described in Section 18 of the *State Access Management Manual.*

B. Scope of Evaluation: A traffic engineering evaluation shall be required when new or modified access facilities are proposed along a state highway to ensure that the operational characteristics of all state highways are maintained at acceptable levels. The evaluation may include, but is not limited to, roadway and intersection level of service calculations, driveway and intersection location and spacing assessments, traffic signal warrant and systems analyses, roadway and intersection design, and safety analysis. The Department shall require a traffic engineering evaluation of access issues for land development projects that request access to a state highway, directly or indirectly, and for highway improvement projects (see Subsection AV of 18.31.6.7 NMAC). The traffic engineering evaluation shall be performed by a registered engineer, authorized under New Mexico Engineering and

Surveying Practice Act (NMSA 1978, Sections 61-23-12 through 61-23-13).

C. Traffic Operational Performance: The operational performance of a highway segment, intersection or access facility is described by level of service (LOS). Level of service is a quantitative measure of roadway or intersection operations and vehicle capacity. Level of service standards are defined by Access Category. Level of service (LOS) F shall not be accepted for individual movements.

D. Establishing Existing Traffic Conditions: Engineering evaluations of traffic and roadway conditions on state highways should be based on current traffic count information. The traffic data will be considered current if it is or has been collected within one year of the date that a scoping meeting is held between the permittee and the District Traffic Engineer, or if otherwise approved for use by the District Traffic Engineer.

(1) Defining the Data Collection Period: The permittee should recommend the periods for traffic data collection at the traffic analysis scoping meeting held between the permittee and the NMSHTD District Traffic Engineer. The periods for traffic data collection may include typical weekday conditions, special traffic conditions, or both.

(2) Typical Weekday Traffic Conditions: Traffic data representing typical weekday conditions should be obtained on Tuesday, Wednesday or Thursday, and may be obtained on Monday or Friday.

(3) Special Traffic Conditions: Special traffic conditions typically occur from 1900 to 2400 hours and from 0000 to 0600 hours on weekdays, and throughout the day on Saturday and Sunday. The duration of special traffic counts should be based on the activity or event and be sufficient to capture the peak travel condition.

(4) Traffic Data for Traffic Signal Warrant Analysis: A minimum of 12 hours of traffic count data for a representative day shall be obtained when conducting a traffic signal warrant analysis. Manual intersection turn movement counts shall be conducted for at least 8 of the 12 hours. The remaining 4 hours of data may be obtained using counting equipment on the intersection approaches, or by conducting a 12-hour intersection turn movement count. It is desirable to conduct an 8-hour manual turn movement count supplemented by 24-hour machine counts on each intersection approach when evaluating the need for traffic signal control on a state highway.

E. Design Hour Volume: Design hour volumes (DHV) should be calculated for the AM peak hour and the PM peak hour of a typical weekday, or for the design hour associated with special traffic conditions. Design hour volume is synonymous with the term peak-hour volume that is used for traffic operations analysis. For land development projects, the DHV should be based on the traffic data collected to establish existing traffic conditions combined with background traffic growth and traffic generated by pertinent site-specific land development. For highway improvement projects, appropriate future year traffic forecasts should be developed to represent the DHV for the facility.

F. Traffic Signals: Traffic signals may be warranted at either public or private access locations due to new land development or the redevelopment of an existing property. The installation of traffic signal control shall be preceded by a traffic engineering evaluation that includes detailed analysis of the need for and an assessment of its impact upon the state highway. The engineering evaluation shall be conducted in accordance with the MUTCD, as clarified in sections of the *State Access Management Manual*, and shall include a traffic signal warrant analysis.

(1) Installation: If the warrant analysis and traffic engineering evaluation indicates that a signal is warranted, the permittee shall be required to provide all of or a portion of the funding for the installation (see Subsection J of 18.31.6.14 NMAC). The funding requirements will be determined by the Department.

(2) Traffic Signal Spacing: The number of traffic signals per mile has a significant influence on travel speed and vehicular delay along a roadway. Acceptable travel speeds and minimal delay occur when sufficient distance and relatively uniform spacing is provided between signals. Traffic signal spacing requirements shall be defined according to the highway functional classification where the intersection is located and shall be more restrictive for higher type roads.

(3) *Operations and Maintenance: The electric power supply and maintenance for a signal* installation shall be the responsibility of the local governmental agency. A Signalization Agreement stating the operation and maintenance responsibilities shall be executed between the Department and the local agency prior to installation of the signal. For land development projects, the signalization agreement shall be the responsibility of the permittee. For highway improvement projects, the signalization agreement shall be the responsibility of the NMSHTD project development engineer.
[18.31.6.15 NMAC - Rp, 18 NMAC 31.6.12.4 & 18 NMAC 31.6.12.5, 10/15/2001]

18.31.6.16 TRAFFIC STUDIES FOR LAND DEVELOPMENT:

A. Purpose: As stated in 18.31.6.15 NMAC, a traffic engineering evaluation shall be required for all land development proposals that may directly or indirectly impact a state highway facility. This section describes the specific traffic study process that shall be followed to address the traffic engineering evaluation requirement for a land development project. The traffic engineering evaluation requirement may be waived by the Department when considering a request for a new individual use access (see Subsection D, Paragraph 1 of 18.31.6.14 NMAC).

B. Traffic Study Approach: A three-tiered approach shall be utilized to satisfy the NMSHTD traffic study requirement for a proposed land development project. Traffic impact study requirements of local governments shall also be followed, where applicable. The NMSHTD three-tiered approach is as follows: First Tier, Site THreshold Assessment (STH); Second Tier, Site Traffic Analysis (STA); and, Third Tier, Traffic Impact Analysis (TIA). Additional requirements and guidelines for conducting the three-tiered traffic study are defined in Section 16 of the *State Access Management Manual.*

C. Site Threshold Assessment: A STH shall be required of all developing or redeveloping properties that directly or indirectly access a state highway. The STH should examine existing roadway volumes and trip generation estimates to determine if additional traffic analysis is required. The NMSHTD STH form should be completed and should be reviewed by the District Traffic Engineer. If the site characteristics and the trip generation estimate for a proposed development do not satisfy the requirements for a site traffic analysis or a traffic impact analysis as determined by the District Traffic Engineer, the STH should be approved and the traffic study requirement for the proposed development will be complete. If additional analysis is required based on the results of the STH, the District Traffic Engineer should indicate to the applicant the level of analysis that is required.

D. Site Traffic Analysis: The purpose of a STA is to evaluate localized impacts of a proposed development. In general, localized impacts include the proposed access drive or drives and the first adjacent major intersection, signalized or unsignalized, in each direction along the state highway where the proposed access is located. The requirements for a STA are described in the following subsections. All site traffic analyses shall be sealed and signed by a registered New Mexico Professional Engineer prior to the issuance of an access permit by the Department.

(1) When is a STA Required? A STA shall be conducted for each new development or property redevelopment along a state highway when:

(a) The results of a STH indicate that the proposed development is expected to generate between 25 and 100 peak-hour total trips, and the adjacent roadway currently has a daily traffic volume greater than an average of 1,000 vehicles per day per lane (vpdpl), or

(b) There are safety concerns along the highway where the development is located that are verifiable by the District Traffic Engineer.

(c) For smaller developments, the requirement to perform a STA may be waived if site-specific improvements identified by the District Traffic Engineer are implemented by the applicant as a condition of the access permit. The improvements shall be implemented prior to permanent use of the access.

(2) When is a STA Complete? A STA is considered complete when a final traffic study report, signed and sealed by a New Mexico registered professional engineer, is submitted to the District Traffic Engineer, and

(a) The results of the STA indicate that the levels of service for the proposed access points and the adjacent intersections satisfy or are better than the applicable LOS standards and the District Traffic Engineer concurs with those findings, or

(b) The results of the STA indicate that improvements are required at the proposed *access points and/or at the adjacent intersections, and a mitigation plan has been developed and approved* by the District Engineer.

(3) Requirements for Conducting a STA: A description of the subject matter that should be included in a site traffic analyses is provided in Section 16 of the *State Access Management Manual.*

E. **Traffic Impact Analysis:** The purpose of a TIA is to conduct a comprehensive analysis of the transportation system that will provide access to a proposed development site, including proposed access points, to identify potential short-term and long-term impacts on the state highway system. The requirements for a TIA are described in the following subsections. All traffic impact analyses shall be sealed and signed by a registered New Mexico Professional Engineer prior to the issuance of an access permit by the Department.

(1) When is a TIA Required? A TIA shall be conducted for each new development or property redevelopment along a state highway when:

(a) The results of a STH indicate that the proposed development is expected to generate 100 or more peak-hour total trips; or,

(b) The results of a STA indicate that expected levels of service (LOS) will be below the applicable LOS standards, and a mitigation plan cannot be resolved between the NMSHTD and the permittee to address identified deficiencies; or,

(c) There are safety concerns along the highway where the development is located that are verifiable by the District Traffic Engineer.

(2) When is a TIA Complete? *A TIA is considered complete when a final traffic study* report, signed and sealed by a New Mexico registered professional engineer, is submitted to the District Traffic Engineer, and

(a) The results of the TIA indicate that the levels of service for the proposed access points and the study area intersections satisfy or are better than the applicable LOS standards and the District Traffic Engineer concurs with those findings, or

(b) The results of the TIA indicate that improvements are required at the proposed access points and/or at the study area intersections, and a mitigation plan has been developed and approved by the District Engineer.

(3) Requirements for Conducting a TIA: A description of the subject matter that should be included in a traffic impact analyses is provided in Section 16 of the *State Access Management Manual.*

(4) *Documentation: All required traffic impact analyses shall include documentation in the* form of a bound report. A sample outline for TIA documentation is provided in the appendix of the *State Access Management Manual.*

F. **Fair Share Cost Analysis:** Based on the impact assessment completed for the STA or TIA, contributory costs of identified improvements should be identified. In addition to implementing the necessary improvements within the highway right-of-way at proposed site access points, the permittee shall be required to provide all or a portion of funding for mitigation of identified off-site impacts. The funding requirements shall be determined by the Department through negotiations with the developer and the appropriate local government agency. Refer to Subsection J of 18.31.6.14 NMAC for the permittee's responsibilities when constructing the required improvements.

G. **Traffic Study Validity Period:** Approved traffic studies should remain valid for a period of one-year following approval of the driveway permit application, or as determined by the District Traffic Engineer.

[18.31.6.16 NMAC - Rp, 18 NMAC 31.6.12.4, 10/15/2001]

18.31.6.17 SPEED-CHANGE LANE REQUIREMENTS:

A. **Purpose:** This section defines the criteria for determining where speed-change lanes are required along non-access controlled and controlled-access state highways that provide access via at-grade intersections. Application guidelines for speed-change lanes on controlled-access interstate highways and freeways, which provide access exclusively by grade-separated interchanges, are also provided; however, specific criteria for speed-change lanes on grade-separated highway facilities are not explicitly defined (see Subsection C of 18.31.6.17 NMAC).

B. **State Highways with At-Grade Intersections:** At unsignalized at-grade intersections, four types of speed-change lanes are used including left-turn deceleration lanes, right-turn deceleration lanes, left-turn acceleration lanes, and right-turn acceleration lanes. At signalized at-grade intersections, three types of speed-change lanes are used including exclusive left-turn lanes, exclusive right-turn lanes, and right-turn acceleration lanes.

(1) Schematic Illustrations: Illustrations of left-turn and right-turn speed-change lanes can be found in the appendix of the *State Access Management Manual.*

(2) Design Period: The need for speed-change lanes should be assessed using the hourly traffic volumes derived for the traffic study implementation year with the proposed development, or based on the future year traffic forecasts developed for a highway improvement project.

(3) General Criteria:

(a) Speed-change lanes may be required by the NMSHTD at unsignalized or signalized access points where specific public safety and traffic operations concerns are identified and documented.

(b) Left-turn acceleration and deceleration lanes should not overlap. Preference should be given to the left-turn deceleration lane. Alternative treatments to providing a left-turn acceleration lane may be considered when this situation arises such as providing traffic signal control or restricting the left-turn movement from the cross street. Alternative treatments require approval by the Department.

(c) Where two access points have right-turn speed-change lanes that overlap, or are in close proximity but do not overlap, a continuous ingress/egress lane may be established between the access points to improve roadway consistency, safety, and to maintain roadway edge continuity.

(d) If the design of an access facility crosses two different speed zones, the speed-change lane design should be based upon the applicable speed limit. The applicable speed for a deceleration lane is the posted speed limit at the beginning of the deceleration lane. The applicable speed for an acceleration lane is the posted speed limit at the end of the acceleration lane.

(e) Acceleration lanes should only be used where sufficient acceleration length can be provided.

(f) On multi-lane highways, the directional hourly traffic volume, or directional split, should be determined based on actual traffic count data. It may be assumed that traffic is equally divided among the mainline travel lanes when traffic count data are not available.

(4) Unsignalized Intersections: In addition to the location of the roadway (urban or rural), the three primary factors used to determine the need for a speed-change lane at an unsignalized at-grade access are highway travel speed, directional traffic volume per lane, and turning traffic volume. Sight distance conditions, level of service, and roadway geometry should also be examined when determining the need for speed-change lanes.

(a) Urban Conditions: The need for left-turn and right-turn deceleration lanes on urban state highways should be determined based on the criteria in Tables 17.B-1 and 17.B-2. Right-turn acceleration lanes may be required on urban state highways with posted speed limits greater than 40 mph where an acceleration lane is necessary for public safety and traffic operations based upon site and roadway specific conditions. Left-turn acceleration lanes may be required on urban state highways with posted speed limits greater than 45 mph where an acceleration lane is necessary for public safety and traffic operations based upon site and roadway specific conditions.

(b) Rural Conditions: The need for left-turn and right-turn deceleration lanes on rural state highways should be determined based on the criteria in Tables 17.B-3 through 17.B-6. Right-turn acceleration lanes may be required on rural state highways with posted speed limits greater than 40 mph where an acceleration lane is necessary for public safety and traffic operations based upon site and roadway specific conditions. Left-turn acceleration lanes may be required on rural state highways with posted speed limits greater than 45 mph where an acceleration lane is necessary for public safety and traffic operations based upon site and roadway specific conditions.

(5) Signalized Intersections: The use of speed-change lanes at signalized intersections is generally consistent for all access categories, urban and rural. Guidelines for determining the need for speed-change lanes at signalized intersections can be found in Section 17 of the *State Access Management Manual.*

C. State and Interstate Highways with Grade-Separated Interchanges: Speed-change lanes are used on controlled-access state and interstate highways at or between grade-separated interchanges. The need for speed-change lanes on grade-separated highway facilities should be determined based on design principles contained in the AASHTO publication *A Policy on Geometric Design of Highways and Streets*, and based on detailed traffic operations analyses of the grade-separated facilities according to Highway Capacity Manual methodologies. The need for and function of speed-change lanes should be documented in an Interchange Management Plan for the interchange (refer to 18.31.6.12 NMAC). Speed-change lanes on grade-separated highway facilities should enable a driver to make the necessary transition between the speed on a ramp and the speed of operation on the mainline highway in a safe and comfortable manner. Additional guidance is provided in Section 17 of the *State Access Management Manual.*

Table 17.B-1
Criteria For Deceleration Lanes On
URBAN TWO-LANE HIGHWAYS

Turning Volume[1] (vph)	LEFT-TURN DECELERATION LANE			RIGHT-TURN DECELERATION LANE		
	Minimum Directional Volume in the Through Lane (vphpl)[2]			**Minimum Directional Volume in the Through Lane (vphpl)[2]**		
	≤ 30 mph	35 to 45 mph	45 to 55 mph	≤ 30 mph	35 to 40 mph	45 to 55 mph
< 5	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
5	510	450	330	1,080	610	360
10	390	330	210	700	400	240
15	320	250	150	500	280	170
20	270	200	120	380	210	140
25	230	160	100	300	180	120
30	200	130	Required	250	160	110
35	170	110	Required	220	150	100
40	150	Required	Required	200	140	Required
45	130	Required	Required	190	Required	Required
≥ 46	Required	Required	Required	Required	Required	Required
	Left-turn Deceleration Lanes are Required on Urban Two-lane Highways for the following Left-turn Volumes: • ≤ 30 mph : 46 vph or more • 35 to 40 mph : 36 vph or more • 45 to 55 mph : 26 vph or more			***Right-turn Deceleration Lanes are Required on Urban Two-lane Highways for the following Right-turn Volumes:*** • ≤ 30 mph : 46 vph or more • 35 to 40 mph : 41 vph or more • 45 to 55 mph : 36 vph or more		

Notes:

1. *Use linear interpolation for turning volumes between 5 and 45 vph.*
2. *The directional volume in the through lane includes through vehicles and turning vehicles.*

Table 17.B-2
Criteria for Deceleration Lanes on
URBAN MULTI-LANE HIGHWAYS

Turning Volume[1] (vph)	LEFT-TURN DECELERATION LANE			RIGHT-TURN DECELERATION LANE		
	Minimum Volume in the Adjacent Through Lane (vphpl)[2]			Minimum Volume in the Adjacent Through Lane (vphpl)[2]		
	≤ 30 mph	35 to 40 mph	45 to 55 mph	≤ 30 mph	35 to 40 mph	45 to 55 mph
< 5	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required
5	Not Required	490	420	1,200	730	450
10	420	370	300	820	490	320
15	360	290	220	600	350	240
20	310	230	160	460	260	180
25	270	190	130	360	230	150
30	240	160	110	290	200	130
35	210	130	100	260	180	120
40	180	120	Required	240	170	110
45	160	110	Required	220	160	Required
50	140	Required	Required	200	Required	Required
55	120	Required	Required	190	Required	Required
≥ 56	Required	Required	Required	Required	Required	Required
	Left-turn Deceleration Lanes are Required on Urban Multi-lane Highways for the following Left-turn Volumes: • ≤ 30 mph : 56 vph or more • 35 to 40 mph : 46 vph or more • 45 to 55 mph : 36 vph or more			***Right-turn Deceleration Lanes are Required on Urban Multi-lane Highways for the following Right-turn Volumes:*** • ≤ 30 mph : 56 vph or more • 35 to 40 mph : 46 vph or more • 45 to 55 mph : 41 vph or more		

Notes:

1. Use linear interpolation for turning volumes between 5 and 55 vph.

2. The volume in the adjacent through lane includes through vehicles and turning vehicles.

Table 17.B-4
Criteria for Left-turn Deceleration Lanes on RURAL MULTI-LANE HIGHWAYS

Left-Turn Volume [1] (vph)	LEFT-TURN DECELERATION LANE			
	Minimum Volume in Adjacent Through Lane (vphpl) [2]			
	≤ 30 mph	35 to 40 mph	45 to 55 mph	> 55 mph
< 5	Not Required	Not Required	Not Required	Not Required
5	450	310	210	130
10	310	220	130	90
15	240	160	100	70
20	190	130	80	Required
25	150	110	Required	Required
30	130	Required	Required	Required
35	110	Required	Required	Required
≥ 36	Required	Required	Required	Required

Left-turn Deceleration Lanes are Required on Rural Multi-lane Highways for the following Left-turn Volumes:

- ≤ 30 mph : 36 vph or more
- 35 to 40 mph : 26 vph or more
- 45 to 55 mph : 21 vph or more
- > 55 mph : 16 vph or more

Notes:

1. *Use linear interpolation for left-turn volumes between 5 and 35 vph.*
2. *The volume in the adjacent through lane includes through vehicles and turning vehicles.*

Table 17.B-5
Criteria for Right-Turn Deceleration Lanes on RURAL TWO-LANE HIGHWAYS

Right-Turn Volume[1] (vph)	RIGHT-TURN DECELERATION LANE			
	Minimum Directional Volume in Through Lane (vphpl)[2]			
	≤ 30 mph	35 to 40 mph	45 to 55 mph	> 55 mph
< 5	Not Required	Not Required	Not Required	Not Required
5	800	460	270	160
10	430	280	170	110
15	290	180	110	80
20	200	140	90	70
25	170	120	80	Required
30	160	110	Required	Required
≥ 31	Required	Required	Required	Required
	Right-turn Deceleration Lanes are Required on Rural Two-lane Highways for the following Right-turn Volumes: • ≤ 30 mph : 31 vph or more • 35 to 40 mph : 31 vph or more • 45 to 55 mph : 26 vph or more • > 55 mph : 21 vph or more			

Notes:

1. *Use linear interpolation for left-turn volumes between 5 and 30 vph.*
2. *The directional volume in the through lane includes through vehicles and turning vehicles.*

Table 17.B-6
Criteria for Right-Turn Deceleration Lanes on
RURAL MULTI-LANE HIGHWAYS

Right-Turn Volume[1] (vph)	RIGHT-TURN DECELERATION LANE Minimum Volume in Adjacent Through Lane (vphpl)[2]			
	≤ 30 mph	35 to 40 mph	45 to 55 mph	> 55 mph
< 5	Not Required	Not Required	Not Required	Not Required
5	910	520	310	180
10	520	330	200	130
15	370	220	140	100
20	270	170	110	90
25	220	140	100	Required
30	200	130	90	Required
35	180	120	Required	Required
≥ 36	Required	Required	Required	Required

Right-turn Deceleration Lanes are Required on Rural Multi-lane Highways for the following Right-turn Volumes:

- ≤ 30 mph : 36 vph or more
- *35 to 40 mph : 36 vph or more*
- 45 to 55 mph : 31 vph or more
- > 55 mph : 21 vph or more

Notes:

1. *Use linear interpolation for left-turn volumes between 5 and 35 vph.*
2. *The volume in the adjacent through lane includes through vehicles and turning vehicles.*

[18.31.6.17 NMAC - Rp, 18 NMAC 31.6.12.7.1 through 18 NMAC 31.6.12.7.6, 10/15/2001]

18.31.6.18 ACCESS LOCATION AND DESIGN STANDARDS:

The location and design of access points along state highway facilities shall be in accordance with standards established by the NMSHTD. These standards are defined below and are expounded on in Section 18 of the *State Access Management Manual.* Where specific design criteria are not provided in 18.31.6.18 NMAC, the design approach should be based on nationally accepted standards and shall be consistent with Department specifications.

A. **General:** The Department has developed these standards to provide guidance for the location and design of access points along state highways, specifically for those highways in access categories UPA, RPA, UMA, RMA, UCOL, and RCOL (see 18.31.6.10 NMAC). These criteria are based upon established design standards meant to protect public safety, to maintain safe and smooth-flowing traffic operations, and to preserve the intended function of all state highway facilities.

(1) Local Standards: Where a local jurisdiction has established more stringent design standards than the Department, the local standards should be applied with the concurrence of the Department.

(2) Material Placed within State Rights-of-Way: Any materials used within state highway right-of-way shall be subject to approval by the NMSHTD. Refer to 18.31.6.14 NMAC for additional requirements regarding construction within state highway right-of-way.

B. **Access Location:** Access points should be located along state highways to minimize turning movement conflicts between adjacent access facilities, and to provide adequate separation of conflicts for oncoming motorists. Stopping sight distance should be considered in determining access point locations.

(1) Direct Access: The number of access points should be limited to one per site unless frontage is adequate and design hour traffic volumes indicate that the operational level of service for a single access is expected to be below the minimum acceptable LOS standards.

(2) Proximity to Speed-Change Lanes: Access should not be permitted within a speed-change lane, or within 50 feet of either the leading or trailing limits of a speed-change lane.

(3) Interchange Proximity: Access shall not be permitted within the access control limits of an interchange, as established by the Department's access control determination, or within 50 feet of the leading or trailing edge of the access control limits for the interchange.

(4) Corner Clearance: Driveway access should be controlled on both the approach and departure sides of an intersection to maintain adequate corner clearances.

(5) Edge Clearance: The location of access points relative to frontage property lines should be based on local requirements. When property frontage is not adequate to comply with local government's edge clearance requirements, shared access should be considered.

C. **Access Spacing:**

(1) Non-Developed and Developing Areas: The spacing of access points in non-developed and developing areas should be based on the access category, the posted speed limit, and the type of access requested (i.e., intersection or driveway). Desired access spacing standards are provided in Section 18 of the *State Access Management Manual.* An applicant may request a variance to the spacing requirements when physical characteristics of a property preclude the desired spacing.

(2) Developed Areas: In developed or redeveloping areas where existing driveway locations preclude access spacing based on desired standards, new access points should be located to minimize conflicts with existing access points. Access points should be consolidated where possible to provide shared property access.

(3) Business Districts: The spacing of access points within business districts on urban or rural highways may be adjusted based on site-specific conditions consistent with the requirements for the access category of the highway.

D. **Median Openings:** New median openings on state highways with non-traversable medians should not be allowed unless a traffic engineering evaluation analyzing all related traffic and safety issues is prepared and approved by the Department. Median openings at intersections or full-access driveways should be spaced with a minimum frequency based upon the access category and posted speed of the highway.

E. **Selection of Design Vehicle:** The design vehicle should be used to determine the geometric characteristics of a roadside access or median opening, and to define the required design components for the adjacent highway. This vehicle should be the largest vehicle that is expected to access the site on a daily basis. Selection of the design vehicle is subject to the approval of the District Traffic Engineer.

F. **Sight Distance:** Sight distance at all access locations shall be adequate to provide safe operating conditions for the motoring public. An access permit should not be issued unless adequate stopping sight distances are provided for motorists passing the access, and adequate entering and crossing sight distances are provided for motorists using the access. The permittee shall maintain adequate, unobstructed sight distance in both directions from the access. Any potentially obstructing objects such as but not limited to advertising signs, structures, trees and bushes, shall be designed, placed and maintained at a height not to interfere with the sight distances needed by any vehicle using the access. Roadway reconstruction may be required to provide adequate sight distance.

G. Driveway Angle: The access centerline should be perpendicular to the state highway centerline and extend tangentially for a minimum distance of 40 feet beyond the near-side edge line. An acute angle between 75 degrees and 90 degrees may be permitted if significant physical constraints exist. Acute angles less than 75 degrees shall require special approval of the Department.

H. Access Radius: The access radius should be designed to accommodate the design vehicle expected to use the access on a daily basis. Access radii apply to driveways that are not urban section driveway cuts.

I. Driveway Width: The width of a driveway should be measured exclusive of radii or tapers. Driveway widths should vary by design vehicle. All two-way driveways should accommodate a concurrent entering and exiting design vehicle, including the design vehicle's off-tracking.

J. Access Connection Depth: The access connection depth should be designed to facilitate the movement of vehicles off the highway to prevent the queuing of vehicles on the traveled way. An access shall not be approved for parking areas that require backing maneuvers within state highway right-of-way. All off-street parking areas must include on-site maneuvering areas and aisles to permit vehicles to enter and exit the site in forward drive without hesitation.

K. Speed Change Lanes: Design specifications for speed change lanes are provided in Section 18 of the *State Access Management Manual*. Schematic illustrations of speed-change lanes are included in the appendix of the *State Access Management Manual*.

(1) Deceleration Lanes: Deceleration lanes typically consist of three components: transition taper, deceleration distance, and queue storage. The length of the lane should allow a vehicle to come to a comfortable stop prior to reaching the end of the expected queue in the lane.

(2) Acceleration Lanes: Acceleration lanes should consist of a full-width lane and a transition taper. Acceleration lanes should be designed so that a turning vehicle will reach a speed between 75 and 80 percent of the highway posted speed at the point where the full-width lane ends and the transition taper begins.

(3) Channelization: Standard roadway signing and marking should be installed for all speed change lanes.

(4) Shoulders: Where shoulders are present along a roadway and speed change lanes are required, the shoulders should be continued along the speed change lanes. A minimum shoulder width of 4 feet should be provided adjacent to speed change lanes.

(5) Bicycle Lane Buffers: When a right-turn deceleration lane or acceleration lane is required on a roadway with designated bicycle lanes, a minimum buffer of 4 feet (5 feet desirable) should be provided between the outside travel lane and the speed-change lane.

(6) Grade Adjustment: Adjustments should be made to the speed change lane lengths based on the roadway grade.

(7) Truck Design: If a speed-change lane is designed for a site with 5 or more large trucks during the design hour, a combination truck design vehicle should be used as the design vehicle.

(8) Pavement: The speed change lane pavement section should be full depth and match the pavement section design of the adjacent roadway. All pavement designs require approval by the Department.

L. Median Design for Turn Lane Installation: Medians should be designed to accommodate the largest design vehicle anticipated to use the access, and may provide either partial or *full access to a site. Where a single left-turn lane is necessary along a state highway, a minimum median* width of 16 feet should be provided. Positive channelization should be provided for all median openings. Median paving should be full depth and match the pavement section design of the existing roadway. The installation of a median opening should not reduce the conveyance or storage capacity of the median, pertinent to its drainage function within the highway section.

M. **Setbacks:** Improvements on public or private property adjacent to the right-of-way should be located so that parking, stopping, and maneuvering of vehicles within the highway right-of-way will not occur.

N. **Access Vertical Alignment:** The vertical alignment of all access locations should be designed to minimize vehicle bounce and prevent high-centering of vehicles with a maximum clearance of 4 inches. The maximum grade for a driveway should be 10 percent for a low volume residential driveway and 8 percent for all other access locations. Steeper access drives require special Department approval. A level area (maximum 2 percent grade) 20 feet in length should be provided at each access to *ensure proper sight distance from the access.*

O. **Roadside Safety:** Careful consideration shall be given to the roadside clear zone. The permittee shall provide adequate clear zones. The roadside clear zone should be designed per the AASHTO *Roadside Design Guide* and applicable NMSHTD standards.

P. **Non-Motorized Considerations:** Access designs should provide for the safe movement of all right-of-way users, including but not limited to pedestrians, bicyclists, and the handicapped. Where non-motorized facilities cross an access point, such as bicycle trails, appropriate modifications should be made to maintain safe operations for both facilities.

(1) Sidewalks: Sidewalks should be constructed along urban arterial and collector state highways. Sidewalks are required where they exist on adjacent properties to maintain consistency along the highway facility. Sidewalk widths should match existing adjacent sidewalk widths, but in any case shall conform with all federal, state, and local regulations and ordinances.

(2) Bicycle Facilities: Bicycle facilities along urban arterials and collectors should be constructed in accordance with the AASHTO *Guide for the Development of Bicycle Facilities.* Bicycle facilities should only be signed where designated by the state or local jurisdiction, with approval of the Department.

(3) ADA: Non-motorized facilities shall be designed in accordance with the Americans with Disabilities Act and applicable NMSHTD standards. Curb ramps shall be provided on urban sections where sidewalk and curb returns exist.

Q. **Lighting:** Where lighting is required at an access point, the lighting design shall comply with NMSHTD and AASHTO standards and the Night Sky Protection Act (House Bill 39). The lighting design shall use full cut-off fixtures, and be consistent with AD 226, Roadway Lighting.

(1) Signalized Access: Illumination should be provided at all signalized intersections in accordance with AASHTO's *An informational Guide to Roadway Lighting* or as otherwise approved by the Department.

(2) Site Illumination: Light beams from on-site lighting systems shall not be directed toward oncoming traffic along the adjacent roadway(s). All site illumination shall be constructed outside of the state highway right-of-way and outside of the roadside clear zone. Theater screens, lights, signs, billboards, signals or other illuminated structures should not be located adjacent to state highways, or in the vicinity thereof, which distract the attention of and impair the safety of the traveling public.

R. **Drainage:** Adequate drainage within state highway right-of-way shall be maintained at all access locations. Drainage of roadside ditches shall not be altered or impeded, and the applicant shall provide suitable and approved drainage structures as required by the Department. All site drainage shall be collected prior to entering state highway right-of-way. Site drainage shall not be permitted to drain into state right-of-way without written approval of the Department. Drainage mitigation design shall be in accordance with Administrative Memorandum 221, Drainage Design Criteria, and the NMSHTD Drainage Manual. Access permit applicants shall submit drainage analysis documentation to the Department prior to changing site drainage conditions.

S. **Right-of-Way Fencing:** Driveways shall not be permitted through an existing right-of-way fence, the continuation of which is necessary for the safety of the traveling public, unless the applicant first agrees in writing to construct and maintain a gate or a cattle guard and additional fence in good repair and to keep the gate closed to livestock. The Department shall determine whether a gate or cattle guard is required. All new fencing along a state highway shall be constructed so that clear sight triangles are provided for ingressing or egressing vehicles. This may require an offset from the right-of-way line to meet the minimum setback standards.

T. **Mailboxes:** Mailboxes installed within the state highway right-of-way shall be constructed in conformance with the rules and regulations of the U.S. Postal Service and the design standards of the NMSHTD. AASHTO's *A Guide for Erecting Mailboxes on Highways*, should also be used for the location and design of mailbox installations.

U. **Right-of-Way:** Improvements adjacent to state highway right-of-way shall conform to the pertinent State Highway Commission Policy regarding right-of-way.

V. **Utilities:** All utilities located within the state highway right-of-way shall comply with the utility accommodation policies defined in the NMSHTD's Railroads and Utilities Manual.

[18.31.6.18 NMAC - Rp, 18 NMAC 31.6.11.3 through 18 NMAC 31.6.11.5; 18 NMAC 31.6.12.1 through 18 NMAC 31.6.12.3; 18 NMAC 31.6.12.6; 18 NMAC 31.6.12.7.7 through 18 NMAC 31.6.12.7.11; 18 NMAC 31.6.12.9; 18 NMAC 31.6.12.10; 18 NMAC 31.6.12.12; 18 NMAC 31.6.12.13; 18 NMAC 31.6.12.14.2 through 18 NMAC 31.6.12.14.4; 18 NMAC 31.6.12.14.6; 18 NMAC 31.6.12.14.7; 18 NMAC 31.6.12.14.10; 18 NMAC 31.6.12.15, 10/15/2001]

18.31.6.19 ACCESS CONTROL REVIEW PROCEDURES:

A. **Purpose:** The Access Control Review Procedures define the process that the Department shall follow when considering requests for permanent breaks in existing access control lines, and/or for establishing or modifying access control limits on new or existing state, federal and interstate highways. Decisions regarding access control matters on state highways shall be addressed by the Access Control Review Committee of the Department. Review and approval of an access break in established access control lines shall be required by the Access Control Review Committee. Refer to the *State Access Management Manual* for further clarification of the Access Control Review Procedures.

B. **Access Control Review Committee:**

(1) Purpose: The purpose of Access Control Review Committee is to review all access control requests by departmental staff members who have the expertise to identify issues that need to be resolved before access control limits are established or modified, or access breaks are recommended for approval.

(2) Authority: The Access Control Review Committee has authority to deny requested access control breaks for existing access control facilities. Access control breaks denied by the Committee may be appealed to the Secretary of Highways or his/her designee.

(3) Quorum Definition: It shall be required that a simple majority of voting members of the committee, or their alternates, be in attendance for a quorum.

C. Operating Procedures:

(1) The two basic functions of the Access Control Review Committee are:

(a) To make recommendations to the Secretary, or his/her designee, on requests for establishing access control on new or existing state, federal and interstate highways; and,

(b) To make recommendations to the Secretary, or his/her designee, regarding requests for permanent breaks in existing access control lines on state, federal and interstate highways.

(2) The Committee shall have the authority to deny access control breaks. A denial by the committee may be appealed to the Secretary, or his/her designee. Any access control breaks permitted shall, as a minimum, be in conformance with criteria contained in the most current edition of this rule, the *Interstate Access Control Policy* (CP 65), and any other applicable statutes, policies or procedures.

D. New or Modified Access Control Limits on State, Federal or Interstate Highways: Operating Procedures of the Access Control Review Committee for requests to establish access control on new highways or existing non-access controlled highways and procedures for modifying access control limits on access-controlled highways shall be as follows. Refer to the *State Access Management Manual* for further clarification.

(1) A request for the establishment or modification of access control shall be received by the Chairperson from a NMSHTD Project Development Engineer or from other government agencies. It shall be the responsibility of the requestor, whether representing the NMSHTD or other government agency, to provide a complete information/request package showing: Location, identified by stationing, distances and proposed right-of-way map; Specific Purpose, defined in a feasibility study or corridor study; and, Source of Funding, for all costs including engineering.

(2) The Chairperson shall request the Right of Way Manager to review the right-of-way map(s) and request Lands Engineering to prepare a draft Administrative Determination prior to review and consideration by the Committee. The draft Administrative Determination should be reviewed by the Project Development Engineer, or requestor, and the Traffic Technical Support Engineer prior to review and consideration by the Committee.

(3) The Access Control Review Committee shall either recommend approval of the draft Administrative Determination as presented or recommend approval based upon committee discussions and recommended modifications. The Access Control Review Committee may also recommend deferral of action on an Administrative Determination to a later meeting if additional information is required by the Committee for evaluation. If the Access Control Review Committee votes to recommend disapproval of a draft Administrative Determination, they shall provide specific reasons to the requestor for their recommendation.

(4) After the Administrative Determination has been recommended for approval by the Committee, it shall be sent to the Secretary, or his/her designee, for review and/or approval or disapproval. The request shall be sent to FHWA for approval if on a federal or interstate highway.

(5) If the request is disapproved by the Secretary or FHWA, it shall be sent back to the Chairperson of the Committee to inform the requestor of the disapproval.

(6) Once all approvals are obtained, the Chairperson shall send all documents to the office of record, which is the Right of Way Bureau Chief's office. The Right of Way Bureau Chief, or his/her designee, shall send a copy of the approved resolution to the owners of record of all affected properties.

E. Requests For Interstate Access Control Breaks: Requests for interstate access control breaks, which are requests for direct access to the interstate or requests that will have a major impact on the operation or function of the existing interchange, ramps, existing crossroad, etc., shall be handled as specified in Commission Policies and Administrative Memorandums.

F. Requests For Non-Interstate Access Control Breaks: Operating procedures of the

Access Control Review Committee for requests for permanent access control breaks within the limits of existing access control rights-of-way on all federal or state highways (other than interstate) shall be as follows.

(1) A request for an access control break shall be received by the Chairperson from a District Office, a Project Development Engineer, an Access Control Study Team, another governmental agency or from an individual from the public or a private firm. For requests that create major impacts (i.e. requires a new interchange or major modifications), it shall be the responsibility of the requestor to provide a complete feasibility study similar to that required for Interstate Access. For requests that may create intermediate impacts (i.e. require traffic signals, require intermediate geometric improvements, etc.), the requestor shall furnish a traffic engineering evaluation or other reports to determine if the requested access is feasible. For access requests that appear to be minor, the request shall be submitted to the Access Control Review Committee for processing.

(2) Once all pertinent information is received, the request shall be placed on the agenda for the next Access Control Review Committee Meeting. The Access Control Review Committee shall consider all pertinent data available concerning the request for a break in the existing access control line.

(3) The Access Control Review Committee shall recommend approval of the access control break as presented; or, recommend approval based upon committee discussions and recommended modifications; or, recommend deferral if additional information is required; or, 4) deny the request. The committee may request that a specific report or feasibility study be conducted if after reviewing the request the Committee considers it to have major or intermediate impacts. If the Access Control Review Committee votes to deny an access control break, specific reasons for the denial shall be provided and a copy shall be sent to the Secretary, or his/her designee. A denial by the committee may be appealed to the Secretary, or his/her designee.

(4) After the access control break (Administrative Determination) has been recommended for approval by the Committee, it shall be sent to the Secretary, or his/her designee, for review and approval or disapproval. After the Secretary, or his/her designee, approves an Administrative Determination for interstate access, the Secretary, or his/her designee, shall prepare a resolution amending the original access control for presentation to the Highway Commission. Highway Commission approval is only needed for requested breaks in interstate access controlled rights of way. The Chairperson shall send a request for approval to FHWA for all interstate or federal highways.

(5) Once all approvals are obtained, the Chairperson shall send all documents to the office of record, which is the Right of Way Bureau Chief's Office. The Right of Way Bureau Chief shall request the appropriate appraisal difference be paid back to the Department.

(6) Once all approvals have been obtained and the appraisal difference has been paid back to the Department, the access-controlled right-of-way becomes non-access controlled right-of-way and the Right of Way Bureau Chief, or his/her designee, informs the requestor and the respective District that the requests for access may proceed contingent on all Department requirements being met. The respective District shall be responsible for making sure all construction is completed in accordance with the Department's regulations and any requirements that were made by the Commission, the Department, or FHWA regarding the approval of the access control break.

G. **Temporary Construction Access Breaks:** Any requests for temporary construction access breaks for projects should be incorporated in roadway plans during their development.

H. **Temporary Access Breaks:** Any request for a temporary access break, which is not related to a construction project, shall be submitted to the Access Control Review Committee for their review and/or approval. The temporary access break does not require an Administrative Determination or approval of the Secretary, but shall have FHWA approval if for a federal or interstate highway. If the

Committee denies a temporary access break, it can be appealed to the Secretary, or his/her designee. If an appeal is approved by the Secretary, or his/her designee, the request must be forwarded to FHWA for their review and approval if for a federal or interstate highway.

I. Access Control Recommendations by Other Government Agencies:

(1) All access control recommendations by other government agencies for federal or state highways shall be submitted to NMSHTD's Access Control Review Committee in compliance with 18.31.6.19 NMAC.

(2) Any and all access control actions/recommendations (made by other governmental agencies) on federal or state highways which have not been approved according to the Access Control Review Procedures shall not be effective until acted on as set forth herein.

[18.31.6.19 NMAC - N, 10/15/2001]

HISTORY OF 18.31.6 NMAC:

Pre-NMAC History:

Material in the part was derived from that previously filed with the State Records and Archives under: SHTD Rule No. 89-1(L), Regulations for Driveways and Median Openings on Non-Access Controlled Highways, 6/9/1989.

History of Repealed Material:

18 NMAC 31.6, Requirements for Driveways and Median Openings on Non-Access Controlled Highways, 12/14/1998.

Other History:

Effective 10/15/2001, 18.31.6 NMAC, State Highway Access Management Requirements, replaced 18 NMAC 31.6, Requirements for Driveways and Median Openings on Non-Access Controlled Highways.

Via personal delivery and via email to jim.griswold@state.nm.us

June 2, 2016

Mr. Jim Griswold
Bureau Chief, New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Mr. David Catanach
Division Director, New Mexico Energy, Minerals, and Natural Resources Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Subject: Initial Response to; Written Request for Extension of Time to Further Respond to; Request for Copy of Application; Request for OCD and Commission Hearing Dockets and Notification of Activity; and, Notice of Possible Future Request for Hearing regarding C.K. Disposal's May 6, 2016 Notice of Application, C.K. Disposal – Surface Waste Management Facility.

Dear Messrs. Griswold and Catanach,

First, to Mr. Griswold, thank you for taking time with me earlier this week to personally explain the New Mexico Oil Conservation Division ("OCD") permit application process.

Louisiana Energy Services ("LES")[1] wishes to comment on C.K. Disposal's May 6, 2016 Notice of Application, C.K. Disposal – Surface Waste Management Facility (attached). The purpose of this response is fivefold: 1.) to provide an initial response within 30 days of Notice per 19.15.36.9.C NMAC, which LES requests the New Mexico Oil Conservation Division ("OCD") take into account prior to issuing a tentative decision regarding C.K. Disposal's application; 2.) to request a 60-day extension of time pursuant to 19.15.36.9.C NMAC, in order to further supplement LES' response with more thorough analysis upon LES receiving a complete copy of C.K. Disposal's Application, which LES understands to contain around 1100 pages; 3.) to request a copy of C.K. Disposal's application for its proposed surface waste facility; 4.) to request that LES be notified of all activity regarding this permit application per 19.15.36.E.2 and 19.15.4.9 NMAC; and 5.) to request that, unless C.K. Disposal's application is denied without further steps taking place, a hearing be held to address LES' concerns regarding public health

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[1] *LES is an enriched uranium manufacturer licensed by the Nuclear Regulatory Commission ("NRC"), and located in southeastern New Mexico, within ½ mile of the proposed C.K. Disposal facility.*

EXHIBIT
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and safety, and the environment including groundwater concerns (LES will additionally and separately file a request with the OCD Clerk at the proper time per 19.15.36.10.A NMAC).

LES supports the need for disposal facilities in support of the oil industry, and LES recognizes the oil industry's contributions to New Mexico. However for the reasons listed below, LES believes that even a tentative approval of C.K. Disposal's application at the proposed location would be unwarranted in terms of producing new and unnecessary risk to the detriment of public health, safety, and the environment, including to the LES site and its employees, land, buildings, and equipment.

C.K. Disposal currently seeks a tentative decision regarding a permit to construct and operate a surface waste management facility in Lots 1 through 4 and the south half of the north half of Section 5, Township 22 south, Range 38 east, N.M.P.M., Lea County, New Mexico.

Another Entity Is Already Doing What C.K. Disposal Seeks To Do, And Does So Without Producing New Unnecessary Risk To The Detriment Of LES Employees' and Visitors' Health Or Safety

There is an existing waste disposal site located to LES' north which does not pose new unnecessary risk to the health safety of LES' employees or visitors. Reasons that the existing facility just north of the LES site does not pose the same concerns include: 1.) the existing site is not operated to the same extent as the proposed C.K. Disposal site, hence the magnitude of atmospheric discharge is less with the existing site than what C.K. Disposal proposes to do; 2.) the existing site is physically located significantly further from LES enrichment plant operations and, accordingly, the existing site is much further from the locations where the majority of LES' staff are located – LES' operations and its approximately 290 employees and 200 contractors are *predominantly located on the south side (not the north side) of LES' property*; 3.) the existing disposal site is significantly further from a main highway thoroughfare and therefore does not introduce a traffic safety concern to LES or its employees or to our federally mandated Emergency Response obligations; and 4.) the prevailing wind conditions based on LES' meteorological measurements are such that the wind predominantly blows from the south to the north, meaning that atmospheric discharge from the existing site is predominantly blown in the opposite direction from the LES site and its employees. Significant meteorological data from the surrounding area was gathered and analyzed for both primary wind direction and wind speeds during the licensing of our facility with the Nuclear Regulatory Commission (NRC). As noted in our Safety Analysis Report (Section 1.3.3.1), docketed with the NRC, the prevailing wind direction is from the south.

For Public Health, Safety, Emergency Response, And Environmental Reasons, It Would Be Unwarranted To Place A Site Such As C.K. Disposal Proposes Adjacent To And Directly Upwind Of LES' Site And Its Employees & Visitors

LES' concerns reside with the lack of justification regarding the risk of placing such an operation as C.K. Disposal proposes *directly adjacent to a strategic national nuclear asset that is continuously manned 24 hours a day, 7 days a week.* According to our meteorological measurements, the prevailing winds from the south will blow atmospheric discharge directly onto LES' site, employees, equipment, and buildings, the consequence of which is the risk of new and unwarranted health and safety risks to LES site personnel and visitors, as well as unknown environmental risks to the land upon which LES is located, and new and unwarranted risk of damage to LES' sensitive equipment.[2]

Relative to employee safety and emergency response responsibilities, additional concerns are as follows: 1.) LES has received no data regarding the nature and type(s) of chemical material and quantities that would be discharged in to the environment, nor has LES received information regarding even more detrimental possible combinations 2.) further, a correlation of this data to allowable federal exposure limits, for example federal ppm standards, has not been provided; 3.) both construction and especially operation of the facility C.K. Disposal proposes would increase heavy truck traffic entering/exiting the highway, but LES has not received any analysis of this type of traffic safety implications; and 4.) as a federally licensed facility, we are obligated to produce and implement procedures, emergency drills and training for postulated accidents on our site as well as response to accidents on adjacent properties – LES has not been presented with sufficient data to understand the impact to our emergency response requirements, memorandums of understanding with medical and emergency response organizations and the highway patrol.

Relative to environmental compliance, LES is licensed to operate under a number of federal requirements imposed through the Nuclear Regulatory Commission, Department of Energy and other federal facilities. Additionally, we are regulated by the State of New Mexico CID and NMED divisions. In the case of NMED we are required to submit environmental discharge reports for our facility on a routine basis that include air discharge, ground water and other measurements. Without further details on the proposed facility, it is unclear how our reporting and monitoring obligations and associated cost may be impacted in order to demonstrate releases from an adjacent operation are not the result of our site performance.

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[2] LES has demonstrated through equipment operation and testing that hydrogen sulfide causes damage to electrical equipment and connections. LES uses highly sophisticated and precise electronics to operate centrifuge technology. Increased air contaminates of this and similar types will require a significant unplanned capital investment to resolve.

Additionally, Another Entity Has Already Applied To Do What C.K. Disposal Seeks To Do Now, But The Other Entity Applied To Use A Location Where We Know Of No New And Unnecessary Risks To The Detriment Of Public Health And Safety

In fact, it has been brought to LES' attention that an application very similar to C.K. Disposal's application has already been filed with OCD for a facility of this type, but which proposes to be located further from the LES site and downwind from the LES site, which would significantly lessen the risk to LES employees' and visitors' health and safety compared to what C.K. Disposal proposes to do and the existing disposal facility north of our site.

To place all this in appropriate context I would like to offer a brief summary of our operation and the value asset we provide to the local community, State of New Mexico and the US Federal Government. For these reasons, we are concerned and intend to fully engage in this process.

In 2006, LES received is Construct and Operate License from the NRC to build the first nuclear project in the United States in almost thirty years. At project completion, LES will have an investment of nearly $5 Billion and will provide enriched uranium for nuclear power generation resulting in 10% of the electricity required for the United States. As the only uranium enrichment plant in North America, LES uses world-leading centrifuge technology to produce this important domestic source of enrichment. LES provides 290 direct, full-time, high paying, safe jobs as well as 200 contracted jobs and is held in high regard by the community as a good corporate citizen. LES and our employees provide the largest donation to the United Way of Lea County each year and our contributions have exceeded $1 Million in the past ten years. We invest an additional $500,000 in the local community in the form of scholarships, sponsorships, and organized community service projects each year. Also, LES utilizes over 150 of its employees to visit 20 schools annually to teach over 2,100 students about science though our Richie Enrichment Science Workshops. LES also provides support to our federal government on matters dealing with international nuclear nonproliferation. As you can see from this brief overview, LES is not only a strategic asset to provide energy resources and security for America, but is also a key employer and community partner for New Mexico.

Finally, please be advised that we intend to broaden the range of chemical constituents we routinely test for at our site boundaries to includes those types of chemicals that could be expected to result from an operation similar to the one proposed. We intend to establish this as a baseline. Should the application process for C.K. Disposal's proposed facility move forward, we will employ this monitoring on a routine basis to confirm applicable federal and state emission standards are continuously met.

Conclusion

As explained above, LES generally supports the need for this type of facility. However, LES, its employees and its visitors should not be subjected to new and unnecessary health and safety risks which C.K. Disposal's plans would expose them to by locating such a site adjacent to and directly upwind of LES, when: 1.) there's already a site doing this very nearby which does not present new and unnecessary risks to our employees' and visitors' health or safety; and 2.) there's another application for a very similar disposal site which is further away from and downwind from the existing disposal site and our facility and hence would not subject LES' employees and visitors to new and unnecessary risks to their health and safety.

LES hereby respectfully requests that a complete copy of C.K. Disposal's application be sent to LES at the address below.

LES hereby respectfully requests an additional 60-day extension of time pursuant to 19.15.36.9.C NMAC, in order to further supplement this LES response with more thorough analysis upon LES receiving a complete copy of C.K. Disposal's Application.

LES hereby respectfully requests that LES be notified of OCD and commission hearing dockets going forward, all administrative activity regarding C.K. Disposal's application, and to be notified of OCD applications generally going forward.

Should the OCD tentatively grant a permit for the facility C.K. Disposal proposes, LES will respectfully file a hearing request with the OCD Clerk pursuant to regulation.

Again, LES appreciates the opportunity to comment on this important application, and **LES respectfully requests that the OCD deny C.K. Disposal's application for its proposed *Surface Waste Management Facility***.

Sincerely,

David E. Sexton
President and Chief Executive Officer
URENCO USA
P.O. Box 1789
Eunice, NM 88231

Tel: +1 575 394 5215
Email: dave.sexton@urenco.com
Web: www.urenco.com

Cc:

ENMRD
Care of F. David Martin, Secretary
1220 South St. Francis Drive
Santa Fe, NM 87505

NMED
Care of Ryan Flynn, Secretary
Harold Runnels Building
1190 St. Francis Drive, Suite N4050
Santa Fe, NM 87505

NOTICE OF APPLICATION
C.K. DISPOSAL – SURFACE WASTE MANAGEMENT FACILITY

Pursuant to 19.15.36, Oil Conservation Division Surface Waste Management Facilities regulations, C.K. Disposal is providing notice that the Oil Conservation Division (OCD) has deemed administratively complete an Application for Permit for a new Surface Waste Management Facility (C.K. Disposal). The Application for Permit was originally submitted to OCD by C.K. Disposal on 11/06/2015. Comments regarding the Application may be submitted to OCD within 30 days of Notice.

1. **Applicant's name and address:** C.K. Disposal, LLC, 5909 86th Street, Lubbock, Texas 79424
2. **Facility location and address:** C.K. Disposal E & P Landfill and Processing Facility is located in Lots 1 through 4 and the south half of the north half of Section 5, Township 22 south, Range 38 east, N.M.P.M., Lea County New Mexico. The site is 0.05-miles south of State Highway 234, approximately 4.16-miles southeast of Eunice, New Mexico.
3. **Brief description of surface waste management facility:** The facility will encompass a total of 316.97-acres with a landfill footprint of 141.50-acres, a liquid processing unit of 57.75-acres, and a saltwater disposal unit of 5.10-acres. At full build-out, the Processing Area will include an oil treatment facility consisting of an estimated 9 produced water load-out points, 12 produced water receiving tanks, 48 produced water settling tanks, 12 evaporation ponds, 5 crude oil recovery tanks, and 5 oil sales tanks; as well as 1 stabilization and solidification area. The landfill consists of six (6) cell that will have a combined disposal capacity of approximately 24,585,056-cubic yards. The landfill method will be below grade fill with 4H:1V side slopes and aerial fill with 5H:1V final cover side slopes, with a maximum 3.5% final cover top slope. The site estimated incoming waste for the life of the facility will vary from 500-cubic yards to 1,500-cubic yards of waste per day. In addition, various support facilities, including: a Processing Area Gatehouse, Landfill Scalehouse, waste acceptance/security features, roads, emergency shower and eyewash station, and stormwater detention basins are proposed for the new Facility. The C.K. Disposal surface waste management facility has been designed and permitted in accordance with NMAC 19.15.36.8 through 19.15.36.20.
4. **Depth and quality of shallowest aquifer:** Based upon information projected from nearby wells, the shallowest potential water-bearing zone in the vicinity is Chinle Formation, which is approximately 225-feet (ft) below ground surface (bgs) at the C.K. Disposal site. In addition, the C.K. Disposal site characterization boring investigation results demonstrate that no shallow groundwater is present above a depth of 150-feet bgs at any of the boring locations. Based on nearby wells, groundwater depth is approximately 225-feet below the site with a maximum TDS concentration of approximately 11,600-mg/L.

Interested parties may contact Jim Griswold, Bureau Chief, Oil Conservation Division at (505) 476-3465 for further information.

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4222 85th Street Lubboc

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Brandt Graham
Legal 2nd CCB floor

URENCO USA
P O Box 1789
Eunice, NM 88231

BG,
Hand delivered

88231$1789

urenco

Via personal delivery and via email to jim.griswold@state.nm.us

June 22, 2016

LES-16-00116-OCD

Mr. Jim Griswold
Bureau Chief, New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Mr. David Catanach
Division Director, New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Subject: LES' Supplemental Comments to Proposed C.K. Disposal Surface Waste Management Facility

References:

1. Notice of Application C.K. Disposal –Surface Waste Management Facility
2. Letter from D. Sexton to J. Griswold and D. Catanach providing LES' initial response to Reference 1, dated 6/2/16.

Dear Messrs. Griswold and Catanach,

Louisiana Energy Services LLC ("LES"), dba URENCO USA ("UUSA") appreciates the opportunity to provide supplemental comments to Reference 2 regarding the proposed disposal facility South of LES' UUSA facility near Eunice New Mexico and the access you provided to the complete application. This access has allowed us to analyze the content of the application and provide more informed comments as noted herein.

As outlined in Reference 2, LES' UUSA facility is an internationally recognized facility that provides uranium enrichment services to customers worldwide. The safety and well-being of our employees and the local community is paramount to us. Additional information about UUSA is contained in Enclosure 2.

We acknowledge that the Permian Basin oil reserves provide enormous economic benefit to the Eunice area and to the state of New Mexico. For this reason, we fully support the oil industry. We're not against the permitting of a facility of the type proposed, within Lea County, however, we do have concerns with siting such a facility directly upwind of our site, which is manned 24 hours a day, 7 days a week and has 490 employees and contractors.

We want to ensure that the health of our employees and visitors is not affected by air concentrations of hydrogen sulfide and other airborne hazardous chemicals. Based on the permit application, the C.K. facility is expected to release levels of hydrogen sulfide and other hazardous chemicals at levels that will be harmful to employees and visitors at the UUSA facility. Because our facility is manned continuously and will operate for at least the next 40 to 50 years, we have a large number of employees who could be exposed to the airborne discharge of such a facility for a very long period of time.

We want to ensure that our employees and visitors are not placed in an unsafe condition by increased road traffic and road conditions on NM HWY 176. This road is already heavily trafficked by trucks and daily vehicle traffic.

The UUSA process contains support systems that are essential to the operation of billions of dollars' worth of assets. These critical systems consist of several uninterruptable power supplies and over a hundred chiller units. Due to the current levels of sulfur compounds in the air, we have seen some degradation of electronic circuit boards that control these systems. The C.K. Disposal plant emissions will increase the hydrogen sulfide emissions and result in escalating repair costs and an amplified risk of loss to our process systems.

UUSA believes in the mission of the Lea County Energy Plex and is supportive of the oil and gas community, but the proposed location and health and safety concerns around it lead us to believe that such a project is better suited to a more remote area of the county that is not adjacent to a continuously occupied facility of strategic national interest.

UUSA's detailed comments are included as Enclosure 1. As you will see, review identified that C.K. Disposal's application is simply insufficient to conclude that it is an acceptable application or that C.K. Disposal's proposed facility can be constructed and operated in compliance with applicable statutes and rules and without endangering fresh water, public health, safety or the environment, and is therefore unacceptable per 19.15.36.12.A. NMAC. Instead, it is only possible to conclude C.K. Disposal's proposed facility presents detriment to fresh water, public health, safety and the environment per 19.15.36.12.B. NMAC.

Again, UUSA appreciates the opportunity to supplement its previous June 2, 2016 comments regarding this important application. Pursuant to 19.15.36.12.A. NMAC, UUSA requests that the OCD not issue a permit for C.K. Disposal's proposed facility. Similarly, and pursuant to 19.15.36.12.B. NMAC, UUSA further requests that the OCD deny the permit for C.K. Disposal's proposed facility.

Respectfully,

David E. Sexton
President and Chief Executive Officer
URENCO USA
P.O. Box 1789
Eunice, NM 88231

Enclosures:

1. URENCO USA Comments on the C.K. Disposal Facility Permit Application
2. About URENCO USA

CC:

The Honorable David Martin
New Mexico ENMRD
1220 South St. Francis Drive
Santa Fe, NM 87505

The Honorable Ryan Flynn
New Mexico Environment Department
Harold Runnels Building
1190 Saint Francis Drive
PO Box 5469
Santa Fe NM 87502

ENCLOSURE 1

URENCO USA Comments on the C.K. Facility Permit Application

I. C.K. DISPOSAL'S PROPOSED WASTE MANAGEMENT FACILITY MAY BE DETRIMENTAL TO FRESH WATER, PUBLIC HEALTH, SAFETY, AND THE ENVIRONMENT AND SHOULD BE DENIED.

A. Detriment to Public Health and Safety

1. Increased public safety concerns arise due to the increase in congestion and other traffic related accidents and issues.

As Item 24 of the NMAC permit application indicates, the division may require additional *information to demonstrate that the surface waste management facility will not adversely impact* public safety. There is no assessment of traffic impacts due to waste delivery to the proposed *facility contained in the permit application; therefore, the potential impact to public safety due to* increased traffic has not been adequately addressed. Further, since both the proposed facility and the existing *URENCO USA facility* utilize the *State Highway (NM 234, also known as NM 176* and Andrews Highway) as access points for their respective entrance gates and employees, the cumulative impacts of the facilities should be evaluated.

Specific Comments:

1) C.K. *Disposal's permit application does not specify the number of anticipated* waste shipments to the facility but has indicated a landfill capacity ranging from 500 cubic yards to 1,500 cubic yards per day. If the typical truck shipment to the site were 20 cubic yards, the number of additional truck trips on the Highway would range from 25 to 75 more trucks per day. Depending on the typical approach to the site (from east of west) there may be impacts and safety concerns for the public due to congestion at the nearest intersection. This truck traffic would be in addition to the normal truck traffic utilizing the highway to reach other destinations and in addition to the routine truck traffic to and from the URENCO USA facility located almost directly across the Highway from the proposed waste facility location. The current URENCO USA truck deliveries and shipments are about 7-10 per day, including shipments of radiological materials.

2) The permit application does not include an evaluation of the proposed location for the entrance to the facility from NM Highway 234 in relation to the existing main gate entrance for the URENCO USA facility. This is an area of potential traffic congestion due to the placement of the new proposed entrance.

3) There has been no evaluation of the individual or cumulative traffic impacts from employee vehicle traffic from the proposed facility or in combination with the adjacent facility for the combined impacts that may be experienced at certain times of the day especially at shift changes.

2. The hydrogen sulfide emissions threaten public health.

In addition to air emissions, the actual impact to human health should be evaluated to assure that the levels in the facility's application are protective and that appropriate monitoring will be conducted. The current proposed waste acceptance level and fence line concentration limit for H2S of 10 ppm is not protective of the public and must be lowered.

19.15.36.12(A) NMAC stipulates that new permits must be constructed to ensure and operated in a such a manner that does not endanger public health:

> "The division may issue a permit for a new surface waste management facility or major modification upon finding that an acceptable application has been filed, that the conditions of 19.15.36.9 NMAC and 19.15.36.11 NMAC have been met and that the surface waste management facility or modification can be constructed and operated in compliance with applicable statutes and rules and without endangering fresh water, public health, safety or the environment."

19.15.36.12(C) NMAC further states that:

> "The division may impose conditions or requirements, in addition to the operational requirements set forth in 19.15.36 NMAC, that it determines are necessary and proper for the protection of fresh water, public health, safety or the environment."

Finally, 19.15.36.17(B) states that:

> "The operator shall ensure each pit, pond and below-grade tank is designed, constructed and operated so as to contain liquids and solids in a manner that will protect fresh water, public health, safety and the environment."

The Application presents proposed methods for ensuring protection of public health and control of H2S odors in Attachment K. The Application states that a trigger level of 10 ppm H2S will be applied at the downwind property boundary, and that if levels exceed 20 ppm H2S at the downwind property boundary, emergency response, including facility evacuation, will take place. Furthermore, and as noted in Section 1, the Application states that all oilfield waste loads will be monitored for H2S upon arriving at the site. If H2S levels exceed 10 ppm, then treatment will be performed to reduce H2S levels prior to unloading shipments.

Specific Comments:

1) Although the Application indicates that H2S will be monitored at potential sources such as the evaporation ponds and at the property boundary, the Application does not indicate if H2S will be released from truck shipments that are being treated to reduce H2S. Furthermore, if H2S is released from trucks that are treated, the application does not indicate how such levels will be monitored at the downwind property boundary, which presumably is directly adjacent to the incoming waste treatment area.

2) The Application does not provide any information concerning the nature of the response *actions that will be instituted at neighboring properties if the monitoring If the H2S* threshold is exceeded at the property boundary, or how the response actions will be coordinated (e.g., through *MOUs*, or access agreements.).

3) The Application does not provide any modeling estimates of H2S liberation or downwind migration. Consequently, the response and contingency plan cannot be placed into context with the likelihood of incurring the need for a response action.

4) The Application does not state whether emergency evacuation requirements are limited to the employees of the applicant or if mandated evacuation of adjacent businesses would be required. Federal regulations imposed on UUSA for the control of special nuclear material require 24 hours a day, 7 days a week continuous protection. Complete evacuation of our facility under any circumstances is not allowed. Further, the Application does not define any detection means, protective actions or emergency actions for an airborne release in excess of proposed limits during non-work hours when the *facility is not open.*

5) *The 10 ppm threshold for H2S is not protective of public health for workers in* neighboring properties. The odor threshold for H2S is 0.01 to 1.5 ppm; this is the range of concentrations where people can detect a rotten egg smell from H2S[1]. The odor becomes offensive in the 3 to 5 ppm range. Prolonged exposure to H2S concentrations in the 2 to 5 ppm range can cause nausea, tearing of the eyes, headaches, loss of sleep and airway problems (bronchial constriction) in some asthma patients[2]. Moreover, NIOSH stipulates a recommend exposure limit of 10 ppm for a 10 minute continuous exposure, after which exposure mitigation is recommended[3]. Similarly, the American Conference of Government Industrial Hygienists (ACGIH) stipulates a threshold limit value (TLV) of 5 ppm for a 15 minute continuous exposure, after which exposure mitigation is recommended.

These values, however, are intended to be applied to individuals who work with H2S as part of their employment, and who have been informed of H2S hazards as part of the workplace right to know regulations. For individuals that are not working with H2S as a component of their *occupation, non-occupational standards apply.* USEPA recommends a long-term time-weighted average (TWA) not to exceed value of 0.006 ppm[4] based on adverse effects to the nervous and respiratory systems[5]. *USEPA also recommends a 24-hour TWA not to exceed 0.07 ppm based*

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[1] OSHA Safety and Health Topics: Hydrogen Sulfide. www.osha.gov/SLTC/hydrogensulfide/hazards.html

[2] Ibid

[3] Centers for Disease Control, National Institute for Occupational Safety and Health (NIOSH). http://www.cdc.gov/niosh/npg/npgd0337.html

[4] USEPA Regional Screening Levels. Composite Worker Air. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016

[5] Integrated Risk Information System. Hydrogen Sulfide. https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=61

on the threshold concentration that produces an allergic response in sensitive human populations[6].

To meet these requirements, the threshold levels at the property boundary must be lowered to be protective of public health. The design, operation and emergency response need to take the requirements into consideration.

B. Detriment to Air Quality, the Environment, and Fresh Water

1. **The air pollutant emissions, based on the type and amount of waste material planned for disposal, pose a threat to the air quality and need to be closely monitored.**

With respect to air emissions, the permit application does not quantify potential or expected actual emissions of regulated air pollutants. The construction and operation of an industrial facility in the State of New Mexico requires an evaluation of whether an air permit is applicable and required for the intended operation [New Mexico Administrative Code (NMAC) 20.2.72 addresses Statewide Air Quality Construction Permitting requirements and NMAC 20.2.73 *addresses Notice of Intent and Emissions Inventory Requirements. Both regulations require the* quantification of hourly and annual emissions of regulated air pollutants including Nitrogen Oxides (NOx) Carbon Monoxide (CO), *Volatile Organic Compounds (VOCs), Sulfur Oxides* (SOx), Total Particulate Matter (TSP), Particulate Matter less than 10 microns (PM10), Particulate Matter less than 2.5 microns (PM2.5), Hydrogen Sulfide (H2S), and Lead. However, the New Mexico air regulations 20.2.72.402(C)(5) specifically exempt Oil & Gas production facilities from being regulated under the state's "Toxic Air Pollutants' program. Oil & Gas production facility is defined under 202.72.401(F) as "facilities for the exploration, development, production, treatment, separation, storage, transport, and sale of unrefined hydrocarbons, natural gas liquids, and CO2 (e.g., major SIC group 13, oil and gas extraction, SIC industry group no. 4612, crude, petroleum, pipeline and SIC industry no. 4922, natural gas transmission)". Regardless of the exemption, a new facility would need to apply for an air construction and operating permit for all other regulated air pollutants, noted above. Please note that it does not appear to meet the definition of an Oil & Gas production facility as 'landfill and water treatment' are not listed and the Standard Industrial Classification (SIC) or North American Industry *Classification System (NAICS) codes are not provided in the facility's application.*

Specific Comments:

1) Fundamental to the permitting process is the calculation of potential emission rates of any regulated air contaminant emitted by the source. The permit application attempts to address odor issues for hydrogen sulfide (H2S), but does not quantify or address emissions of particulate matter, volatile organic compounds (VOCs), or hazardous air pollutants (HAPs). Quantifying the level of emissions from proposed evaporation ponds, air stripper, truck loading/unloading and tank venting should be addressed.

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[6] Agency for Toxic Substances and Disease Registry (ATSDR). Acute Minimum Risk Level for hydrogen sulfide. http://www.atsdr.cdc.gov/mrls/pdfs/atsdr_mrls.pdf

2) The stated purpose of the evaporation ponds and the water processing operation is to generate marketable water. The application notes that "volatiles and dissolved gasses can be problematic in other treatment activities as well as oil and gas use. The treatment goal of the stripping tower is to minimize these harmful constituents in effluent water" and "at this time, expected air would simply be off-gassed to the ambient atmosphere." This process includes a seven-foot diameter air stripper whose air emissions are not completely described and remains unquantified. The permit also states that iron compounds, manganese compounds and chlorides are anticipated corrosives in the waste stream. These would likely be emitted to the air in addition to any volatiles and should be addressed.

3) The application does not anticipate or address any air dispersion modeling. The state of New Mexico has recently published draft guidance for the oil and gas production industry to streamline the air permitting of compressor stations. The draft guidance specified that modeling is not required if the facility meets several requirements including that H2S emissions not exceed 0.01 pounds per hour (lbs/hr) and the facility not be located at least 2,634 feet (or 800 meters) from a source that emits over 25 tons per year of NOx. Although this is not a direct correlation, as the application for a disposal and processing facility is not the same as a compressor station; emission levels and air dispersion modeling should be addressed in the application to determine if the emission rate from the facility meets applicable standards.

4) The application proposed to monitor H2S in the headspace (presumably) of delivery containers. This screening method does not directly correlate to quantities processed by the facility or the emission rates anticipated from the operations at the proposed facility. A trigger level of 10 parts per million (ppm) and a treatment to 1 ppm in the headspace does not quantify the VOC and H2S concentrations in the material itself. The emissions generated by processing the material cannot be correlated to headspace concentrations at the time of delivery.

5) With respect to air emissions, if the water processing unit operates at the levels included in the application (12,000 barrels per day, 24 hours per day, seven days per week) and assuming a VOC concentration of 200 ppm, the annual potential emissions of a 90% efficient stripper exceed 130 tons per year. The potential emissions of VOCs are greater than the 100 tons per year major source limit and therefore would require a Title V air permit. This permit was not noted in the facility's application.

2. The evaporation ponds that collect contaminated discharge pose an ecological risk

The New Mexico environmental regulations state that "The application shall include.... other information that the division may require to demonstrate that the surface waste management facility's operation will not adversely impact fresh water, public health, safety or the environment...." (NMAC 19.15.36.8C (17)). The proposed development of this facility has not addressed potential impacts to the immediate environment caused by the construction of the 317-acre facility.

Areas subject to surface disturbance should be evaluated for the presence of sensitive habitat and/or Rare, Threatened, or Endangered species. This is usually accomplished through the completion of some type of biological inventory and clearance. An on-the-ground inspection by a qualified biologist should be required to quantify, using elementary survey sampling techniques, the types and numbers of plants, mammals, birds, reptiles and amphibians. In cases where sensitive species are affected, the preferred response would be to modify the proposed action to avoid the species or its habitat (avoidance). If avoidance of a threatened, endangered, or sensitive species or its habitat is not possible, consultation with USFWS would be required and a biological assessment would be prepared to recommend actions to protect the species or its habitat. A list of species that the biologist should be aware of can be obtained from the New Mexico Department of Fish and Game (e.g. "Threatened and Endangered Species of New Mexico").

In addition to the requirements above, ponds attract migratory birds. In Section 1.9 of the Permit application, C.K. Disposal, LLC states the following:

> "C.K. Disposal LLC herein requests an exception to 19.15.36.13.I NMAC. The Migratory Bird Protection Plan presented as describes an alternate methodology to the screening requirement of the storage ponds. This Plan describes visual inspections and migratory bird retrieval and clean up procedures should bird(s) require decontamination."

There was no indication in the Permit application that a detailed "Migratory Bird Protection Plan" was presented. The southeastern region of New Mexico is an important component of the "Central Flyway" and therefore, since significantly large ponds will be present, these waterbodies will undoubtedly attract migrating waterfowl that have been observed in southeastern New Mexico including ducks, geese, herons, pelicans and swans.

Specific Comments:

1) C.K. Disposal should institute and plan Best Management Practices for the protection of migratory birds. The application states that "Visual inspections" and "migratory bird retrieval and clean up procedures" will be conducted, however these will not protect migratory birds from the exposure to environmental contaminants. At a minimum, personnel trained in the capture, handling and/or cleaning of birds will be necessary within a reasonable time frame if a bird is in jeopardy.

2) Birds at the disposal facility may be exposed to environmental contaminants that could affect individuals by reducing reproduction or survival. The uptake of contaminants from ponded environments is of particular concern. Contaminants in soils may erode and become concentrated within ponds. These metallic and organic compounds accumulate in aquatic sediments and also may accumulate or biomagnify in the tissues of aquatic organisms. The facility should conduct routine and scheduled sampling of surface water and sediments and action should be taken if concentrations are above some predetermined regulatory benchmark. Best management practices for contaminants should include the ongoing evaluation of ecological risks and the communication of any risks to management. An ecological risk assessment should be included in the permit application to help prioritize future environmental remediation.

3) Mitigation measures for environmental contaminants may include identifying and reporting birds that are found with deformities or areas with high numbers of unexplained bird mortality. The proposed evaporation ponds that receive contaminated effluents should be evaluated for risk to bird species such as swallows which make heavy direct use of ponded waters and associated insects. If these ponds present an unacceptable risk, they should be covered so that they are unavailable to migrating species. Regular maintenance should be conducted to ensure covered ponds remain unavailable. Ecological risk assessments should consider impacts of contaminants to migratory birds most at risk. Information from these assessments should be used to prioritize mitigation of ecological risk. Finally, the use of integrated pest management techniques to minimize the use and exposure to pesticides should be considered.

3. Groundwater is threatened by inadequate testing and monitoring.

In general, the application (Attachment G – Hydrogeology Report) presents the geology and hydrogeology of the region with only limited site data. Five soil borings were completed, but no soil or groundwater samples were collected to support this evaluation.

Section 3.4 of Attachment G states that because the facility is "not permitted and thus has no existing groundwater wells, there is no existing analytical data". Groundwater wells should be installed in support of the permit process and to obtain site specific data. Instead of relying on published data from the region, quarterly groundwater samples should be analyzed for the constituents required by OCD and should be collected for a minimum of one year, to be able to evaluate seasonal fluctuations, and establish baseline conditions. Furthermore, the groundwater wells would also provide information on the physical properties of the aquifer below the facility.

Although no groundwater monitoring wells were installed, or are proposed to be installed, the facility has proposed a Vadose Monitoring Plan (Attachment H).

This plan is based on sentinel shallow vadose monitoring points to be installed around the facility. A simple vadose model (such as HYDRUS-1) should be employed to model potential releases and to evaluate if the plan is appropriate for the setting and amount and types of materials that could be released to the environment. Unfortunately, the soil properties needed for such a model (and required by OCD) were not collected and were not found in published literature for the shallow Ogallala Formation. As noted in Section 3, these data should be collected and then used to evaluate potential contaminant migration in the vadose zone before the Vadose Monitoring Plan (Attachment H) and Sampling Plans (Attachment I) are approved.

II. THE DIVISION SHOULD NOT APPROVE C.K. DISPOSAL'S UNACCEPTABLE APPLICATION, BECAUSE IT FAILS TO IDENTIFY OR ADDRESS THE INFORMATION NECESSARY FOR A PROPER EVALUATION.

A. The geology and hydrogeology data provided in the application, is insufficient to establish base line data for the permit and fails to meet the application requirement—under Subsection C(15) of 19.15.36.8. NMAC.

Item 22 of the OCD Application for a Surface Waste Management Facility requires the following site-specific information be included in the application so that the base line data is understood. These requirements are provided below, including an evaluation to determine if each were met:

1) A map showing names and locations of streams, springs, or other watercourses, and water wells within one mile of the site.

   Although this is a desert setting and there are few, if any, surface water features, the scale of the map is difficult to read.

2) Laboratory analyses performed by an independent commercial laboratory, for major cations and anions, benzene, toluene, ethyl benzene, and xylenes (BTEX), RCRA metals, and total dissolved solids (TDS) of groundwater samples of the shallowest fresh water aquifer beneath the proposed site;

   No groundwater samples were collected from the site. A total of five (5) soil borings were completed to 175 feet below ground surface (bgs), knowing that groundwater was encountered at approximately 225 feet bgs. Site specific data should be collected for at least four (4) quarterly rounds to establish a baseline for groundwater quality of the shallowest freshwater aquifer. Samples should be submitted to an independent commercial laboratory for analysis of the parameters listed above.

3) Depth to, formation name, type and thickness of the shallowest fresh water aquifer;

   A detailed geologic description of the region is provided in the application; however, it is based on published literature and boring logs conducted by others. The site characterization effort did complete five borings on site to characterize soils, but each boring was terminated in the Ogallala formation, and was not completed to a sufficient depth to characterize the Chinle formation where the shallowest freshwater aquifer is encountered. Furthermore, as noted before, soil samples were not collected to meet the requirements of Item 7, below.

4) Soil types beneath the proposed surface waste management facility, including a lithologic description of soil and rock members from ground surface down to the top of the shallowest fresh water aquifer;

   As noted above, the application refers to published literature to describe the geology and lithology of the soil and rock members below the proposed facility. Borings completed were terminated in the Ogallala Formation and did not extend into the shallowest aquifer.

5) Geologic cross-sections

   Geologic cross sections were completed, however because the borings were not completed in the Chinle, they do not represent hydrogeologic conditions, but rather the *soils above the water table and therefore do not extend to the depths needed to adequately present site conditions.*

6) Potentiometric maps for the shallowest fresh water aquifer

   Potentiometric maps for the site included previously published maps for the site of Eunice and do not extend to the proposed facility. Groundwater wells and contour maps should be developed for the site to establish groundwater flow direction and support a baseline evaluation to characterize groundwater. This is specifically important as the facility plans groundwater injection as part of its process, making the baseline data critical in the evaluation of potential environmental impacts.

7) Porosity, permeability, conductivity, compaction rations and swelling characteristics for the sediments on which the contaminated soils will be placed.

   No soils data were analyzed from the borings and instead, previously published values were used from regional borings. These are not site-specific, as local conditions may vary. Furthermore, the soil properties of porosity, specific capacity and storativity for the Ogallala formation (the shallow formation that will underlie the facility) were not listed. These are several of the parameters that are critical for vadose modeling.

In addition to not meeting the minimum requirements specified by the permit application, the facility is also planning for groundwater injection. However, there are no groundwater models to evaluate how this process could impact the current hydrogeology, nor is there mention for a permit for conducting such activities.

B. Financial assurances estimates in the application are unsatisfactory and fail to properly address the application requirements of a closure and post-closure plan— under Subsection C(9) of 16.15.36.8. NMAC.

As part of the permit application requirements, the facility must provide a cost estimate for closure activities. The permit application offers $2.3 million for closure activities with the financial assurance maintained by bond, letter of credit, trust, or other forms acceptable under NMAC 19.15.36.11.E). Although the application states that the specific method of financial assurance will be determined later, we believe that this cost is conservatively low and omits several significant items. Following are some examples potential under estimation of closure cost for the Oil Treating Plant, Landfill Cell, and Pond Closures. Please note that the specific comments are based on the costs provided in the application.

Oil Treating Plant Closure

1) The permit offers a cost of $25,000 for the removal of the tanks. Per the Site Operations Plan, the total tankage on the completely built out facility will include:
   - 16 produced water tanks (1,000 bbl each)
   - 48 settling tanks (1,000 bbl each)
   - 5 crude oil recovery tanks (1,000 bbl each); and

- 4 oil sales tanks (1,000 bbl each)

Per NMAC 19.15.36.18(D)(1)(a), this item must include that all tanks be emptied, cleaned and removed (disposed of, re-used or recycled). All wastes from the cleaning must be disposed of at an approved facility. The cleaning and disposal of 73 tanks (totaling over 3 million gallons of storage) will cost significantly more than $25,000. It is our opinion that $25,000 is closer to the cost for a single tank (including cleaning, dismantling, transportation & disposal of contents and cleaning solutions, and removal and transportation of the tank) and does not represent the projected costs of all tank closure.

2) The permit offers a cost of $25,000 for the closure and removal of Process Equipment. Per the Site Operations Plan, the total process equipment at the built-out facility may include:
   - One Boiler;
   - Four Mechanical oil-water separation units;
   - One Air Stripping Tower;
   - Four Greensand Filters;
   - One Reverse Osmosis unit; and
   - An unknown amount of process piping.

   Per NMAC 19.15.36.18(D)(1)(a), this item must include that all process equipment be emptied, cleaned and removed (disposed of, re-used or recycled). All wastes from the cleaning must be disposed of at an approved facility.

   The cleaning and disposal of 11 pieces of process equipment will cost significantly more than $25,000. It is our opinion that $25,000 is closer to the cost for a single piece of equipment (including cleaning, dismantling, transportation & disposal of contents and cleaning solutions, and removal and transportation of the equipment).

3) The permit estimates $10,000 for earthwork. The tasks included in earthwork are not clearly defined, however, it is assumed that the earthwork task may include the following items, which would appear to be required under NMAC:
   - Removal of receiving tank liner system;
   - Removal of tank and equipment foundations;

   There are likely additional earthwork tasks regarding the treatment area. However, even these small tasks would typically cost more than the $10,000 allocated.

4) There are no costs for the required soil sampling and analysis:
   Per (NMAC 19.15.36.18(D)(1)(b)):

   "the site is sampled, in accordance with the procedures specified in chapter nine of EPA publication SW-846, test methods for evaluating solid waste, physical/chemical methods, for TPH, BTEX, major cations and anions and RCRA metals, in accordance with a gridded plat of the site containing at least four equal sections that the division has approved"

Based on the size and various operations at the site, it is also likely that substantially more than the minimum four sections will be required to meet the closure requirements.

Landfill Cell Closure

The Financial Assurance estimate only includes the closure of one 23.6 acre cell of the landfill. *In order to meet the permit requirements, the costs to close the full facility (approximately 142 acres)* must be included. This is relevant in the case of a closure initiated by the agency or abandonment.

Unit costs for many of the cap construction elements appear conservatively low. The estimate includes an area which is nearly exactly 23.6 acres and does not account for side slopes, which will increase the surface area over an aerial determination of 23.6 acres when shown in plan view. While we disagree with the assumption of only using 23.6 acres, the estimate accounts for an area that is 80% side slope and only 20% of the more costly "cap". This is a very specific situation which reduces closure costs substantially (4.66 acres of geomembrane and geocomposite in the 23.6 acre closure). Other specific comments pertaining to the cost estimated are provided below:

1) Infiltration layer (24")
   - Standard compaction of the sand layer is not included in the estimate. 7.5% additional sand is standard practice.
   - Costs for the sand layer are extremely low. Costs must include:
     - Purchase (borrow) and hauling of sand layer (For comparison RSMeans 310516100500 for load at pit, haul 2 mile round trip, spread with 200 HP dozer shows $30.56 per LCY for Roswell). It is anticipated that costs would be higher due to a longer haul
     - *Compaction: Compaction costs are not included (RSMeans* 312323240400 for sheepsfoot roller, 8" lifts, select fill shows $1.35 per ECY for Roswell).

2) Soil Erosion layer (12")
   - Soil must be imported in order to support vegetation.
   - Costs for the soil layer are extremely low. Costs must include:
     - Purchase (borrow) and hauling of the topsoil (Means 310513100800 for topsoil borrow, weed free, load at pit, haul 2 mile round trip spread with 200 HP dozer shows $35.59 per CY for Roswell).
     - Compaction Costs should be similar to those for the sand infiltration layer.

3) Missing costs. There are no costs presented for the following items:
   - Establishment of Vegetative Cover. Specific requirements are in place in NMAC 19.15.36.18(D)(2)(b), for vegetative cover, including type and coverage. (Means

329219131000 shows mechanical seeding for large areas including lime, fertilizer and seed at $0.68 per square yard for Roswell - $78k for one cell and $467k for entire landfill)

- With the potential for H2S gas in the landfill components, the lack of installation of a gas control layer is a concern.

Pond Closure

The *Cost Estimate seems to underestimate many of the* quantities and costs associated with the evaporation pond closures. According to the design drawings, each pond it approximately 400' by 200' (80,000 sf) at the surface. There are 12 ponds on the facility, for a total area of evaporation ponds of 960,000 square feet. The removal and disposal of liquids is estimated at 286 bbl (or 8,608 gallons, or 1,151 cubic feet). This would equate to approximately 0.01" (one one-hundredth of an inch) of water across the areas of the pond). It is more likely that the water that needs to be removed from the ponds after operations have ceased will be measured in feet *and not hundredths of an inch. One foot of water across all ponds would equate to* approximately 238,000 bbl of water.

1) The removal and disposal of sludge is estimated at 4,444 tons. Using an approximation of 1.5 tons per cubic yard, this is a total of approximately 3,000 cubic yards or 81,000 square feet. This would be approximately 1" of sludge across the area of the ponds. It is more likely that the amount of residual sludge in the ponds will be measured more in feet of sludge than inches.

2) The transport and disposal cost of $21.50 per ton appears low. Based on the required haul distance as well as the anticipated characteristics of the waste, the transportation and disposal costs are anticipated to be much higher.

3) The omission of backfill fill material (e.g., 0 cubic yards) that will be required for the pond backfill and contouring is of concern. It is not believed that suitable backfill material will be available on-site. The placement and compaction of only 11,853 yards (approximately 4" deep over the area of the 12 ponds) also seems to be an underestimation of what is required.

Post-Closure Cost Estimate

Per NMAC 19.15.36.18, the following elements must be included in the post-closure of a landfill for a period of 30 years:

- Maintenance of cover integrity;
- Maintenance and operation of a leak detection and leachate collection and removal system; and
- Operation of gas and groundwater monitoring systems.

Comments on estimate:

1) Engineering Estimate:
   - Vadose zone monitoring/lab/reporting costs are low. The task must include obtaining the sample, shipping the sample to the laboratory, analyzing the sample and provide an annual report of the results to the agency, comparing the results to standards. A cost of $400 per sample appears low for this.
   - Groundwater sampling/analysis/reporting is not included in this estimate. Identical types of costs as for the vadose monitoring must be included. As noted above, there are no existing groundwater monitoring wells on site, and no wells are proposed. Site specific groundwater data must be obtained so that closure activities may document changes to groundwater quality as a result of facility operations.

2) Construction and Maintenance Costs
   - Cap and Side slope repair costs seem low, as the proposed cost of $3,000 per year for 126 acres of cap. Assuming that one membrane repair or revegetation is required each year over the 30 years, it is unlikely that $3,000 would cover the cost of a cap repair. *Revegetation of even 1% of the landfill (approximately 1 acre) per year* would exceed the annual budget, outside of heavy equipment and earthwork required for cap or side slope repair.
   - *Mowing costs of $25 per acre seem low. For comparison, RSMeans 320190191660* for Mowing brush, light density, tractor with mower, shows a cost of $48.84 per 1,000 sf.
   - *No costs, as required, for the operation and maintenance of the leak detection system* are included in the estimate.

3) Leachate Management

   - No costs are included for the operation or maintenance of a leachate recovery system.
   - The HELP model *indicates significant volumes of leachate will be generated, as* part of the permeable sideslopes proposed in the design. The $4,000 per year is not sufficient for the removal and disposal of tens of thousands of gallons of leachate that will be generated. Substantially more costs for operations and maintenance of a leachate removal system, and transportation and disposal of the collected leachate will be required.

Overall, the cost estimate for closure is likely substantially understated in the permit application, and therefore will require far less financial assurance putting NMED at risk. The estimate should be revised to include all required activities and to be inclusive of all structures that will be removed, or areas to be capped or backfilled. The estimate should also include realistic values for each proposed action.

III. CLOSING

The permit application submitted for C.K. Disposal lacks technical merit for several important categories and does not have a baseline dataset to be able to evaluate how the proposed operations may impact the environment.

Additionally, as UUSA has demonstrated, C.K. Disposal's application is simply insufficient to conclude that it is an acceptable application or that C.K. Disposal's proposed facility can be constructed and operated in compliance with applicable statutes and rules and without endangering fresh water, public health, safety or the environment, and is therefore unacceptable per 19.15.36.12.A. NMAC. Instead, it is only possible to conclude C.K. Disposal's proposed facility may be detrimental to fresh water, public health, safety and the environment per 19.15.36.12.B. NMAC.

Pursuant to 19.15.36.12.A. NMAC, UUSA requests that the OCD not issue a permit for C.K. Disposal's proposed facility. Similarly, and pursuant to 19.15.36.12.B. NMAC, UUSA further requests that the OCD deny the permit for C.K. Disposal's proposed facility.

ENCLOSURE 2

About URENCO USA

- UUSA represents a 5 billion dollar investment made by our parent company, URENCO LTD, based in Stoke Poges, England. The Eunice NM facility is one of 4 enrichments plants owned by URENCO Ltd. The other plants are located in the Netherlands, Germany and the United Kingdom.
- The plant is a strategic national asset for nuclear enrichment and currently provides for over 5% of total electricity use nationwide.
- UUSA actively participates with the federal government in projects to deter nuclear proliferation.
- UUSA routinely host visitors from the local community, all government agencies and positions, from across the US and other many other countries. Typically, UUSA hosts 1000 visitors annually.
- UUSA is an industry leader in employee benefits and compensation. UUSA provides life, health, vision, dental, disability and pet insurances. 401K, Roth and company pension retirement plans are also provided. Additionally, Employee Assistance and Legal Assistance programs are available. A gym and fitness center is located on site for employee use with focus on health and wellness.
- Currently the largest contributor to the Lea County United Way. Over $1,400,000 has been donated since 2008.
- Awards $150,000 in college scholarships annually and offers summer internships to approximately 20 students annually.
- Company employees annually present science workshops at surrounding schools. In 2015, 150 employees presented to 2100 students.
- Hosts a variety of community events. Some examples are the Women's Symposium, United Way Chili Cook-off, Robotics Expo and LEGO League.
- Each year, around September 11, employees volunteer to help local families with home maintenance and repair. All materials are provided by URENCO USA. Since 2008, employee volunteers have repaired 135 homes.

Chapter 13

H_2S Pollution and Its Effect on Corrosion of Electronic Components

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Additional information is available at the end of the chapter

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1. Introduction

The microelectronic industry applies materials with good electrical and corrosion resistance properties for the manufacturing of the microelectronic devices. Silver and copper are materials with this characteristics used for that purpose. Some of their main applications are as high thermal conductive die attach paste that had silver flakes as conductive filler material, silver plated over copper frames, Sn-Ag and Sn-Cu alloys for solder paste used in Surface Mount Technology (SMT) process, conductive internal copper layers in printed circuit boards, copper wire bonding, and more. Other metals and alloys, widely used for support frames, heat diffusers and case wares in the electronics industry are tin, nickel, aluminum, carbon steel and galvanized steel.

Corrosion in microelectronics depends on several variants such as the package type, materials involved, assembly processes, moisture, inorganic and organic contaminants, atmospheric pollutants, temperature, thermal stress and electrical bias.(P. Roberge, 2000, J. Payer, 1990, M.Reid et al., 2007, M. Tullmin and P. Roberge, 1995, M. McNeil and B. Little, 1992, X. Lin and J. Zhang, 2004)

The plastic packages are the more widely used because of its size, cost and manufacturability advantages but, compared to other hermetic package systems like ceramics, are non-hermetic due to its polymeric materials that permit the permeation of moisture and corrosive gases, allowing in this manner the appearance of other problems associated with corrosion of the inside components. Therefore, the advances in the

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microelectronics technology that have promoted the developing of devices with smaller and thin components, and the exposition of these devices to environments where temperature, humidity and atmospheric pollutants like chlorides, NO_x,, SO_x, COS and hydrogen sulfide (H_2S) which are not completely controlled, can favor atmospheric corrosion on their metallic components. Small quantities of corrosion products are enough to induce reliability issues and even catastrophic failures in the microelectronic devices due to the formation of insulating layers by the corrosion film.

In order to minimize the risk of corrosion failure it is important to be aware of corrosion damage during the design stage, reliability evaluations and qualifications, assembly processes, storage, shipping, and in the final use of the microelectronic devices.

Atmospheric contaminants such as H_2S and carbonyl sulfide (COS), that promote the corrosion of silver and copper, are dissolved in the thin layer of electrolyte over metals as a consequence of even low relative humidity (RH) and produce the HS^- ion which is their main reduced sulphur constituent at neutral pH. When silver is exposed in an environment containing a minimum concentration of these contaminants (<1ppm), the corrosion product formed is silver sulfide (Ag_2S). A similar process of sulphidation occurs when the exposed metal is copper that reacts with H_2S producing copper sulfide (Cu_2S). Several studies have been done on the indoor corrosion of silver and copper and revealed that silver sulfide is the main corrosion product on silver that had been exposed indoors. These corrosion films can form an insulating layer on the contact surfaces causing electrical failures on the microelectronic devices.

When silver alloys are exposed in a sulphur-rich environment, corrosion products of the most reactive metal are produced. That is the case of Ag-Cu, where the principal corrosion product is Cu_2S or in alloys of silver with palladium where the corrosion product is Ag_2S. (T. Graedel, 1992, D. Rice et al., 1981, C. Yang et al., 2007, H. Kim, 2003, M. Watanabe et al., 2006, C. Kleber et al., 2008, J. Franey et al., 1985, M. Watanabe et al., 2005, S,. Sharma, 1978, P. Vassiliou and C. Dervos, 1999, g. Russ, 1970, L. Veleva et al., 2008)

Corrosion kinetics depends on the type of metal and also is related to the nature of the electrolyte, atmospheric contaminants and corrosion products. Two kinetic corrosion laws are known for silver kinetics in indoor environments. Silver sulphide, which is a film with low corrosion resistance, obeys a linear corrosion law while AgCl a more protective corrosion layer presents a parabolic behavior. (L. Veleva et al., 2008)

Morphology of corrosion film on silver does not tend to be uniform because of the presence of dendrites or whiskers. Dendrites are fern-shaped and grow across the surface of the metal as a consequence of moisture capable of dissolving the metal and then the ions are redistributed by electro migration in presence of an electromagnetic field. When there is a thick layer of corrosion products, thin filaments projected at a right angle to the surface, called whiskers, begin to grow spontaneously even at room temperature and without an applied electric field. Several cases have been reported where tin whiskers caused failures. (B. Chudnovsky, 2002)

This chapter describes the more relevant results got from the study of silver corrosion at indoor conditions in companies dedicated to assembly and functional test of microelectronics devices. To achieve this, silver coupons and silver plated copper leadframes were exposed in two sites of the assembly process. In addition these materials were exposed in a test chamber that simulates indoor conditions of a plant with no controls for outdoor atmospherics contaminants.

On the other hand, in the electronics industry of Mexicali city located in the State of Baja California, Mexico, there are a variety of devices and electronic equipment inside the plants which are exposed to environments with no climate control and air pollution.

The electronics equipment suffers from corrosion, as humidity levels, sources emitting pollutants such as CO, NOx and sulphide penetrate thought cracks or air conditioning systems. Corrosion phenomena affect connections of electronic equipment (Frankel, 1995) and other electronics components protected with plastic or metallic materials. Atmospheric corrosion is an electrochemical phenomenon that occurs in the wet film formed on metal surfaces by climatic factors (Table I). The corrosion products form dendrites or whiskers in the metallic joints and connectors (Nishikata, et al 1995, Nishimura et al, 2000).

There are obvious differences in outdoor and indoor environments and consequent differences between outdoor and indoor corrosion behavior (Lyon et al, 1996). The corrosion of metals as copper in indoor environments may be viewed as a variation of outdoor atmospheric corrosion. In contrast to outdoor exposure, in an indoor environment the wet film on the metal surface is thinner and it is often governed by relatively constant controlled humidity conditions. Sometimes the indoor environment temperature and RH are controlled and as a consequence, the amount of adsorbed water on surfaces is minimal and is constrained within reasonably tight limits. Since atmospheric corrosion occurs when moisture is formed on the metal surface and depends on its duration and corrosion intensity increases (Veleva et al, 2008).

Factors	Measuring instrument	Unit
Humidity	Hygrometer	%
Temperature	Thermometer	°C
Atmospheric pressure	Barometer	mmHg
Solar radiation	Pyranometer	W / m^2
Pluvial precipitation	Rain gauge	mm
Wind direction	Wind vane	°Grade
Wind speed	Anemometer	m/seg

Table 1. Climatic factors and their measurement

2. Chemistry of sulphidic corrosion

H_2S is a weak, reducing acid, soluble in water with a ionic dissociation:

$$H_2S \leftrightarrow H^+ + HS^- \leftrightarrow 2H^+ + S^{2-}$$

H_2S attacks steel:

$$Fe+H_2S \rightarrow FeS+H_2$$

The FeS layer of steel is not stable, it is removed from the steel surface in an acidic environment, forming again H_2S, enhancing corrosion:

$$FeS+2H \rightarrow Fe^{+2}+H_2S$$

H_2S reduces the Fe^{+3} present in rust: $Fe_2O_3.n\ H_2O$:

$$2Fe^{+3} + 3H_2S \rightarrow 2FeS + 6H^+$$

$$2Fe^{+3} + H_2S \rightarrow 2Fe^{+2} + S + 2H^+$$

Other metals, applied an electronic device e.g. Ag, Cu, Sn, undergo similar reactions forming unstable metallic sulfides.

Under oxidizing conditions H_2S is converted into sulphuric acid, a strong corrosive agent:

$$H_2S + 2O_2 \rightarrow H_2SO_4$$

For silver and copper at atmospheric conditions, the general reaction are explained as follows:

$$2Ag + H_2S + ½\ O_2 \rightarrow Ag_2S + H_2O$$

$$2Cu + H_2S + ½\ O_2 \rightarrow Cu_2S + H_2O$$

$$Cu + H_2S + ½\ O_2 \rightarrow CuS + H_2O$$

3. H_2S toxicity

It is appropriate to report in the context of the present paper the toxicity of H_2S since this also affects quality of the environment and human health, central issues of modern society. H_2S gas emitted into the atmosphere from municipal sewage, industrial plants, animal farms, geothermal wells and polluted sewers and ports (M. Schorr and B. Valdez, 2005) causes inflammation of the eyes, skin burns and respiratory diseases such as rhinitis, bronchitis and pneumonia. When inhaled in small amounts, the gas produces headaches and nausea; a large amount produces paralysis. H_2S is very toxic, rapid death ensues from exposure to air containing > 1000 ppm H_2S owing to asphyxiation since it paralyses the Fe-phorphirin molecule in the human respiratory system. Lower doses cause dizziness and excitement because of damage to the central nervous system. Causes of the death of workers *following the release of H_2S from sewage installations and from plant for the removal of* sulphur from natural gas have been reported. (M. Schorr et al., 2006; S.E. Manahan, 1993)

4. Case studies

4.1. Corrosion behavior of silver and silver plated copper leadframes in H_2S polluted outdoor and indoor environments

In order to evaluate their corrosion behavior, metallic silver coupons and silver plated copper leadframes were displayed per triplicate during a period of 60 days between the summer months of July, August and September in three different sites. Two of the sites were inside and outside the clean room along the assembly process of a microelectronic company and the third one was on a sheltered test chamber (105 x 45 x 65cm in size of aluminum sheet 0.6mm thick material) to simulate indoor environment at uncontrolled flow of atmospheric contaminants O. Vargas et al, 2009).

The test chamber was located in a ventilated place at 10 m over the ground level. In parallel an exposition of metallic silver coupons was followed during a period of 12 and 24 months in the test chamber exposure site to study silver corrosion over a long period of time.

The exposure assembly was developed in Mexicali, Baja California, which is an urban semi-arid zone near to the Cerro Prieto geothermal power plant, the largest and oldest geothermal field in México.Prior to their exposure, the rectangular metallic silver coupons (99.95% pure and 10 x 5 x 1mm in size) were polished with silicon carbide (SiC) abrasive papers to 1200 grit, then were fine polished on a nylon cloth using a 3μm diamond suspension and finally were rinsed with deionized water and dried with nitrogen gas flow (Figure 1).

The leadframes materials, used for a wide range of microelectronics devices, consist in a copper frame with a silver electroplated die paddle and leads to provide mechanical support to the die during the assembly process and for external electrical connection. Dimension of silver plated area is 6x6 mm with a thickness of 6.5μm (Figure 2).

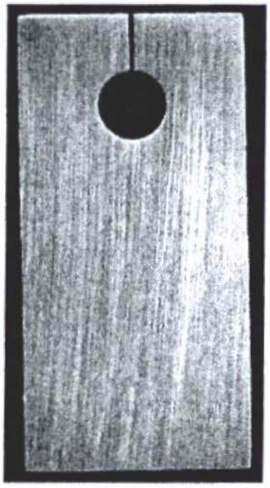


Figure 1. Metallic silver coupon

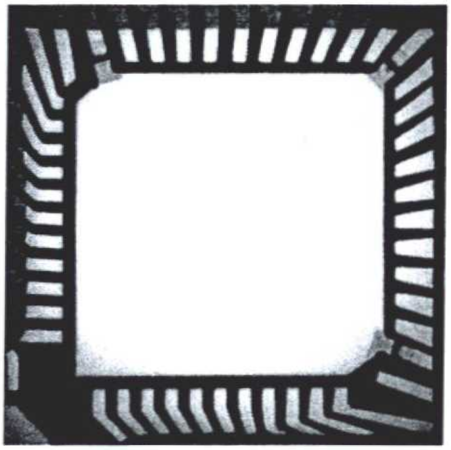


Figure 2. Silver plated on copper frame

The temperature, relative humidity (%RH) and main atmospherics contaminants were monitored and recorded during all the testing time. The morphology of samples was obtained with a JEOL JSM-6360 Scanning Electron Microscope (SEM) and the elemental microanalysis of corrosion products was performed using an EDAX brand Energy Dispersive X-ray Spectroscopy (EDS) detector attached to the SEM.

H_2S is a critical air pollutant in Mexicali. The formed thin AgS layer on the Ag surface in presence of H_2S prevents its adhesion toward the solder material thus making problematic the low resistance contact formation after the soldering process causing an increase of the device failure percentage. To determine the rate of corrosion provoked by H_2S of the silver frames used in microelectronics devices production, the Quartz Crystal Microbalance (QCM) technique was applied at controlled laboratory conditions simulating the indoor conditions. This technique allows the real time determination of the corrosion rate and the formed AgS layer average thickness. The mass gain is calculated applying the Sauerbrey equation:

$$\Delta F = -Cf \cdot \Delta m$$

with: ΔF = frequency change in Hz; Cf = sensitivity factor of the crystal in Hz/ng/cm2 ; Δm = mass change per unit area in g/cm2 . For 1 inch diameter 5 MHz quartz crystal Cf = 0.0566 Hz/ng/cm2 according to the data provided by QCM producer Maxtek (USA).

The Sauerbrey equation allows the real time determination of the mass gain and hence the corrosion rate of Ag provoked by H_2S as well as the thickness of the formed AgS layer. Family of curves in coordinates: QCM frequency - time was registered for different H_2S concentrations while the temperature was held constant and the relative humidity was monitored.

5. Corrosion process

Average values of temperature and RH during exposure of samples are shown in Table 2. These values were similar in the two sites inside the assembly process of the plant and were more aggressive in the test chamber used to simulate indoor conditions.

Atmospheric corrosion frequently occurs in the presence of a thin moisture layer that forms on the metal under certain environmental conditions. The layer may vary from monomolecular thickness to clearly visible water films. Above the critical value of 50% RH at room temperature, the metal is covered by physical adsorption with more than 3 molecular water monolayers (Table 3). This aqueous layer acts as an electrolyte and allows the incorporation of atmospheric contaminants. The critical RH for different metals in sulfur rich environments has been reported to be between 50 and 90%. (P. Marcus, 2002)

The time of wetness (TOW) is the period of time during which, due to the atmospheric conditions, is formed the moisture layer on the surface of metal and the corrosion process can occurs. When relative humidity raises the 90% and temperature is $0° \leq t \leq 25°C$ the dew point is reached and the humidity surface layer on metal becomes thicker. (ISO 9223, 1992)

According the RH registered data and temperature during the exposure, the three exposure sites presented the conditions for atmospheric corrosion of metallic silver coupons and silver plated copper frames.

Exposure Site	Temperature (°C)		Relative humidity (%)	
	Min	Max	Min	Max
Inside clean room	19.44	27.83	32.7	64.2
Outside clean room	19.16	27.33	36.5	65.3
Test chamber	24.36	46.46	10.83	89.9

Table 2. Temperature and relative humidity values during the exposition time

RH%	Water monolayers
90	8 on Ag
80	5-10
60	2-5
40	1.5-2
20	1

Table 3. Approximate number of water monolayers on different metals versus relative humidity

During the exposure time hydrogen sulfide (H_2S) was present, because the activities of vapor exploitation at Cerro Prieto geothermal power plant. When the geothermal fluid is processed to produce electricity, emissions of non-condensable gases are released into the atmosphere. The main involved gases normally are carbon dioxide (CO_2) at around 90%, followed by H_2S with only 2-3% by weight of total gases and, in lower proportion methane, ammonia, nitrogen, hydrogen, mercury and radon. H_2S is a pollutant with a characteristic odor of rotten eggs even at low concentrations, which affects the air quality, induces health damages and it is very corrosive. (H. Puente and L. Hernandez, 2005)

Anthropogenic activities in the region contribute to the increase of H_2S. An automatic air pollutant monitoring station that belongs to the California Environmental Protection Agency located in the nearest has shown an average concentration of 0.9 ppm during the year. Other important atmospheric contaminants monitored by this station are listed in Table 3. (L. Veleva et al., 2008)

Indoor corrosivity indexes (IC2-IC3) for silver and copper has been reported for the Mexicali urban semi-arid environment in evaluations performed in a sheltered test chamber. (L. Veleva et al., 2008, ISO 11844-1, 2000)

Appearance of tarnish film on silver coupons and silver plated copper frames at the end of 60 days of exposure in the three sites can be appreciated in Figure 3 and are described in Table 5.

Contaminant	Average of Min. and Max. Concentration (ppm)
Carbon monoxide (CO)	8.39 to 12.04
Nitrogen oxide (NO)	0.029 to 0.061
Ozone (O_3)	0.03 to 0.10
Sulfur dioxide (SO_2)	0.029 to 0.086
Hydrogen sulphide (H_2S)	0.1 to 0.5

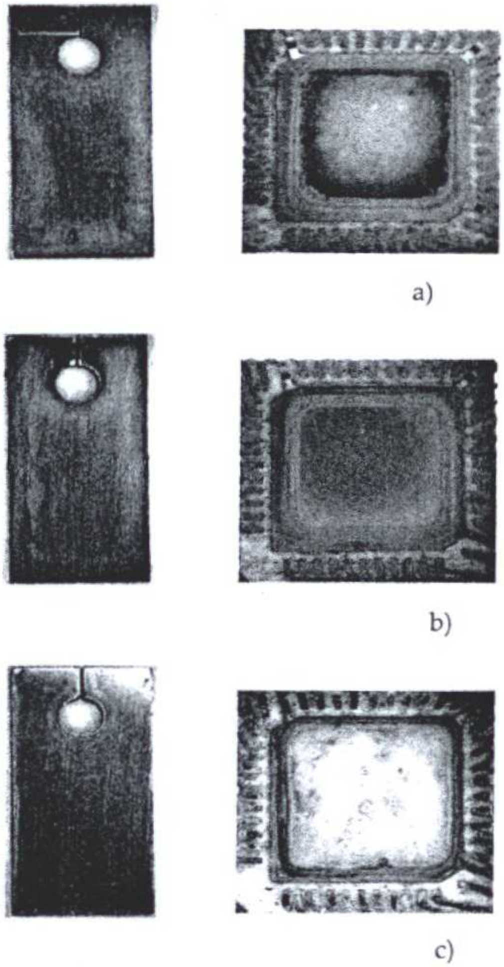
Table 4. Average of annual concentrations of atmospheric contaminants

Exposure Site	Silver Coupons	Silver plated over leadframe
Inside clean room	Royal blue coloration in the center and slightly surrounded by purple in the edges.	Light gold coloration surrounded by purple and blue in the edges.
Outside clean room	Gray coloration in the center and slightly surrounded by purple in the edges.	Purple and blue coloration in the center surrounded by squared shaped lines of purple and royal blue. Small stains were observed in the purple centered area.
In test chamber	Uniform gray coloration.	Gray coloration surrounded by royal blue in the edge. Several purple and dark stains were observed along the silver plated surface.

Table 5. Appearance description of samples after 60 days of exposure

The coloration of the tarnish film depends on its thickness. As the silver sulfide film becomes thicker it turns also darker. C. Yang et al, 2007)

After each exposure time, the samples were analyzed by SEM and EDS in order to observe the corrosion products morphology and chemical composition. In the case of metallic silver coupons, it was observed an uniform morphology with absence of dendrites or whiskers, and the presence of silver sulfide (Figure 4). For the case of silver plated on copper frames, they presented dendrites along the corrosion film (Figure 5). Punctual microanalysis was performed over representative areas with and without dendrites and was noted that, the areas with dendrites presented just a little higher silver sulfide composition but in general composition in both areas was similar in the case of samples coming from inside and outside the clean room.



a)

b)

c)

Figure 3. Tarnishing appearance of silver coupons and silver plated copper frames, after 60 days of exposure: a) inside the clean room, b) outside the clean room and c) in test chamber.

Dendrites can cause failures in electrical equipment by short circuits when they bridge across components or between pads. Dendrite growth depends on the applied voltage, the quantity of contamination and surface moisture. This growth involves an anodic dissolution of the metal, electro migration of the ions and a subsequent cathodic deposition.

In the test chamber samples microanalysis it was detected in the corrosion film, the presence of copper sulfide in addition to silver sulfide. Figure 6 shows corrosion products of copper that comes from underneath the silver through the porosity of the plated layer. EDS microanalysis confirmed the composition of rich zones with corrosion products of copper. This could be

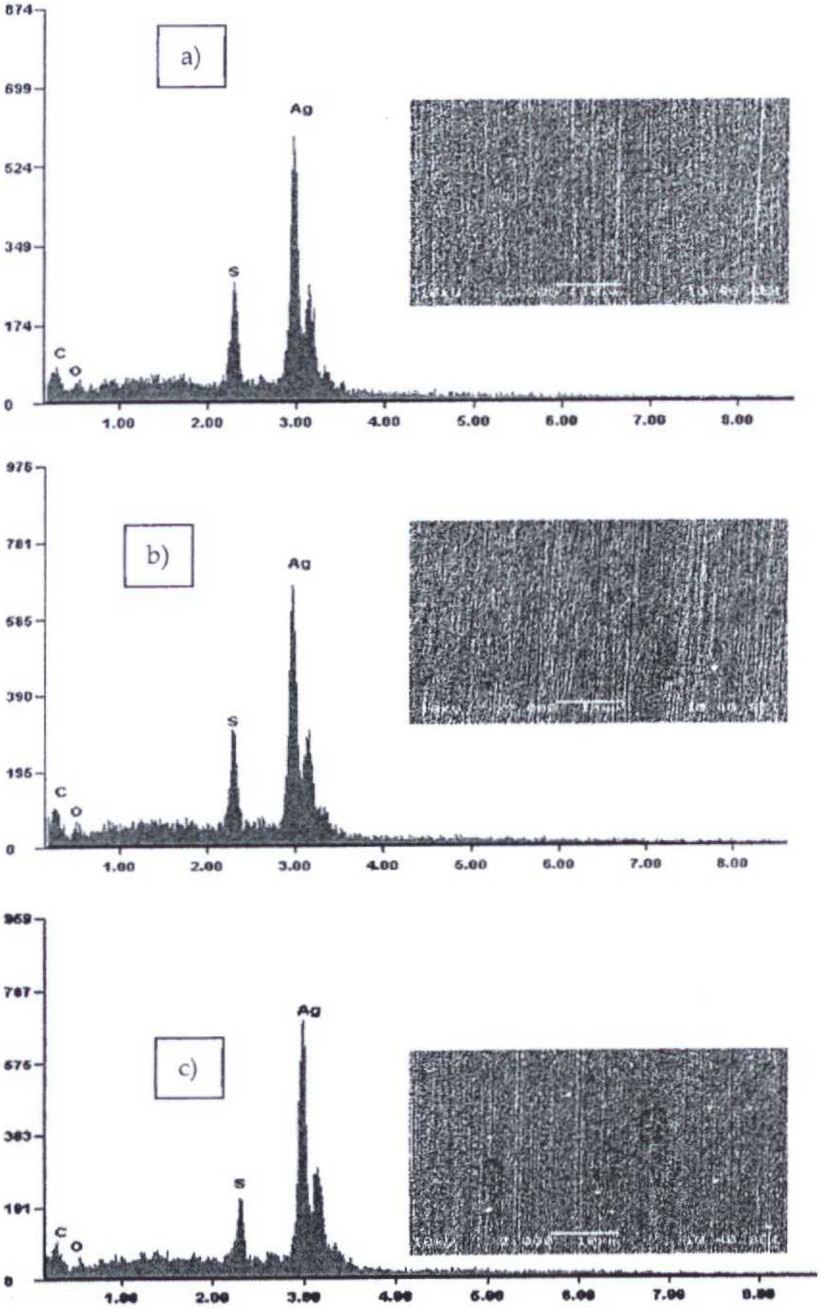


Figure 4. Results of SEM and EDS analysis of metallic silver coupons after 60 days of exposure: a) Inside clean room b) Outside clean room and c) Test chamber.

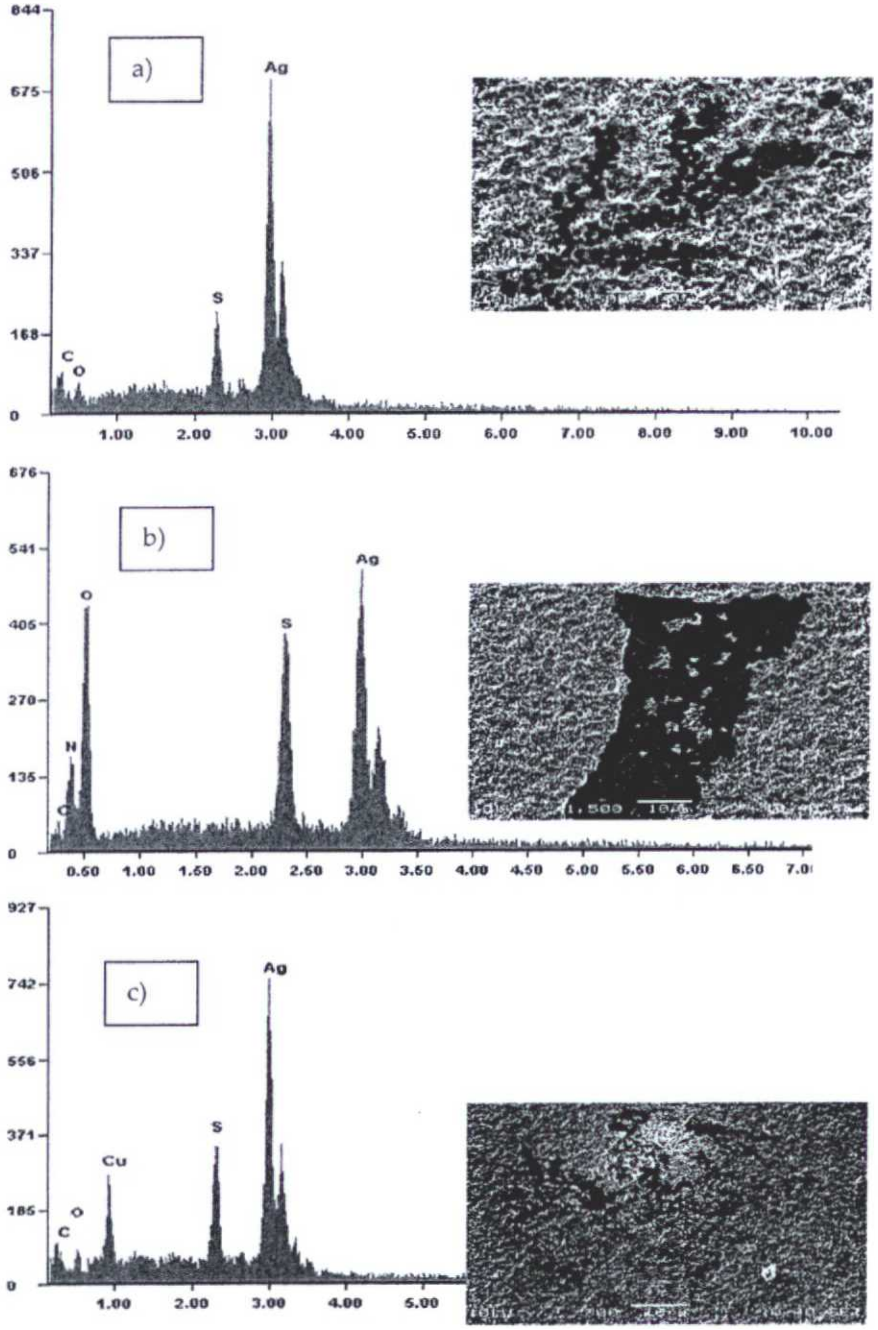


Figure 5. Results of SEM and EDS analysis of silver plated on copper frames after 60 days of exposure: a) Inside clean room b) Outside clean room and c) Test chamber.

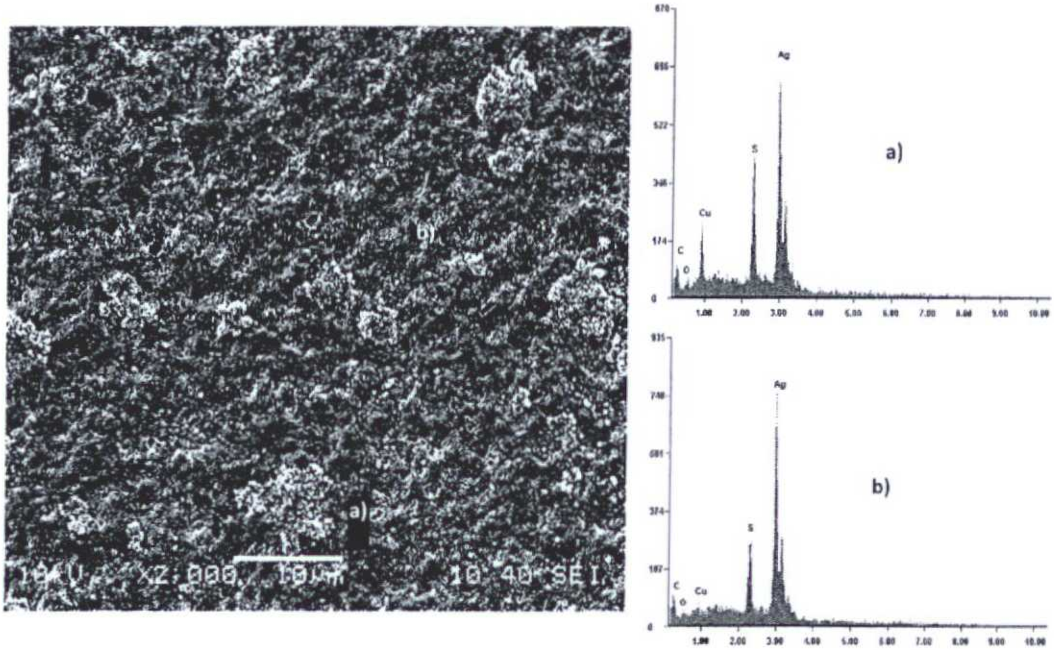


Figure 6. Corrosion products of copper in two different points (a and b) that comes from underneath the silver through the porosity of the plated layer.

happen in this site due to the higher conditions of RH and temperature. The thickness of the silver plated over copper is a very important factor in the reliability of microelectronics, when they are exposed in corrosive environments. A thick silver coating without porosity is highly recommended to avoid influences of the copper substrate on the corrosion mechanism for these materials.Regarding the exposure of metallic silver coupons to study silver corrosion over a long period of time, the presence of dendrites was observed after 12 months and after 24 months, thin branched whiskers were formed on the surface of silver (Figure 7 and 8).

Since whiskers are elongated single crystals of pure metal, they are highly conductive and can cause short circuits and arcing in the electronic and microelectronic devices. There are different shapes of whiskers, they can be straight, kinked, hooked, or forked, and some are reported to be hollow. High temperature and certain thickness of silver sulfide (Ag_2S) are factors that favor the rapid growth of whiskers. (B. Chudnovsky, 2002)

6. QCM technique application for mass gain

This QCM technique was applied for real time determination of the mass gain and hence the corrosion rate and the AgS layer average thickness. The specimens were Maxtek, 5 MHz, one inch in diameter polished quartz crystals covered by Ag on the active surface having a diameter of ½ inch. The temperature was held constant (25 °C) and the RH were monitored applying a Hygro-Thermometer Data logger during the experiment. The average registered RH value was 38.7 % with fluctuations during the experiment of +/-5.6 %.

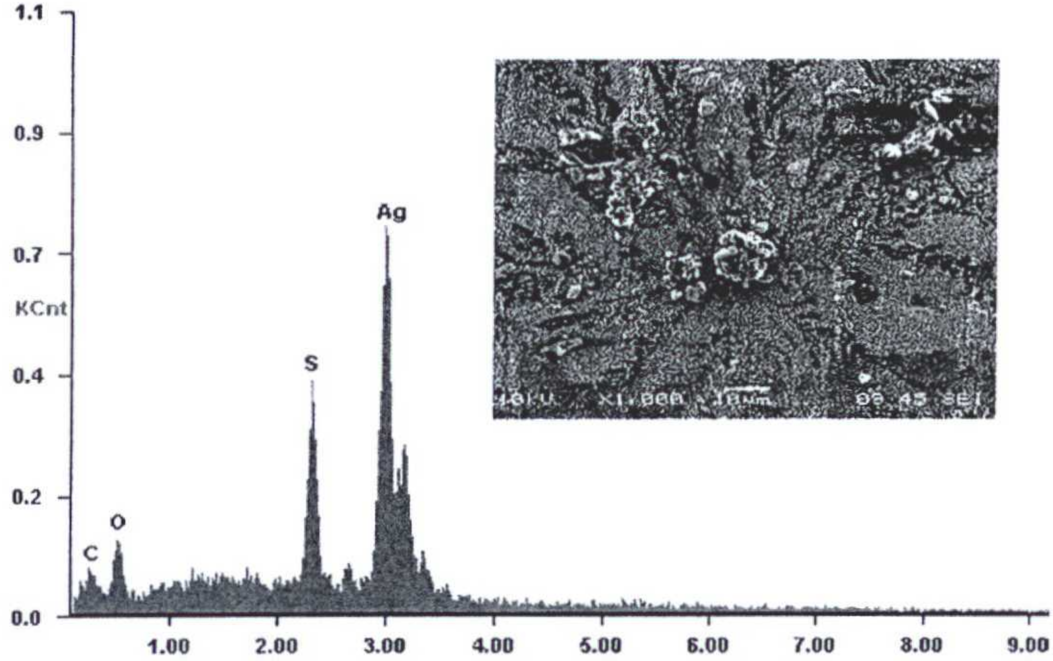


Figure 7. SEM and EDS analysis results for silver after 12 months of exposure in the test chamber.

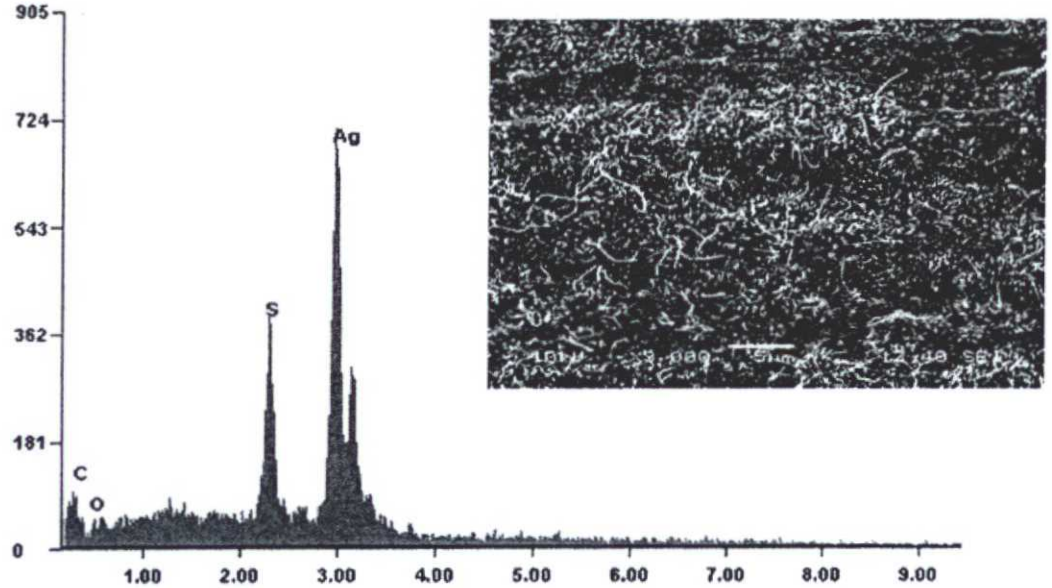


Figure 8. SEM and EDS analysis of metallic silver coupon after 24 months of exposure in the test chamber.

The controlled H_2S concentrations were achieved by additions of known volumes of H2S gas to the transparent plastic chamber containing, the covered by Ag one inch in diameter QCM quartz crystal serving as a specimen. A set of Frequency – Time curves were registered for H2S concentrations in the range 0.05 to 1 ppm which values represent the minimal and the maximal concentrations of this pollutant, while the average annual value for Mexicali was found to be 0.1 ppm (B.G. Lopez et al, 2007). The frequency – time curve for 0.5 ppm H_2S concentrations is shown on Figure 9. The change of the curve slope about the 1000th minute can be explained with the thickness increasing of the formed AgS layer, thus making difficult the further H_2S gas diffusion through it in order to reach the fresh Ag surface. Using the curve shown on Figure 9 it was calculated that the rate of the AgS formation for the first 700 s represent 6.14 ng/cm.s while for the next part of the curve it falls almost twice to 3.27 ng/cm.s. The calculated rate of AgS thickness increasing is 6 nm/s, for the first part of the curve and 3.19 nm/s for the second part. These values showed that the AgS layer formation is very fast even at ambient temperature defining the need of measures to be taken for Ag surface protection.

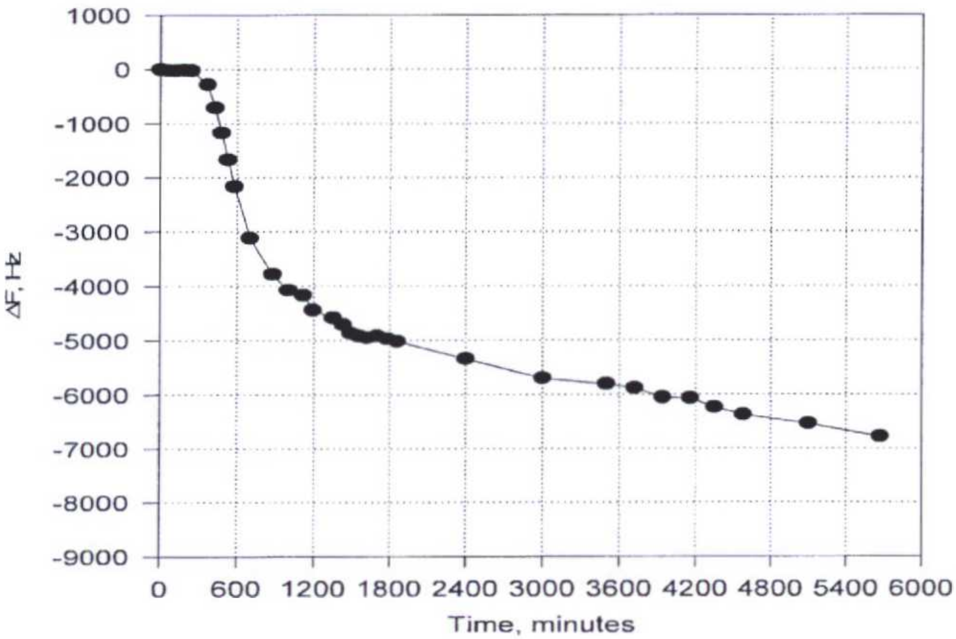


Figure 9. QCM Frequency – Time curve of active Ag surface at 25 °C, 38.7% RH and 0.5 ppm H_2S

Results of exposed silver coupons and silver plated copper frames during 60 days revealed that the indoor environment in the plant can induce silver corrosion, due to the presence of hydrogen sulfide high RH and temperature that favor the corrosion process. There was no difference between the corrosion behavior of samples inside and outside the clean room environment. In the two groups of samples a silver sulfide film was detected. Silver plated copper frame samples presented in addition, growth of dendrites in the corrosion film.

On the samples exposed in the sheltered test chamber corrosion products of copper were noted due to the porosity of the silver plated copper frame.

Regarding the silver coupons exposed in the test chamber used to study the corrosion behavior in a long period of time, growth of dendrites after 12 months and growth of whiskers after 24 months was observed.

The results obtained at the plant, where the study was carried out, indicate that it has not adequate controls to avoid the penetration of outdoor atmospheric contaminants into the assembly process, including the clean room.

7. Corrosion of copper, carbon steel, tin, nickel and silver in H_2S polluted outdoor and indoor environments

7.1. Exposure of metal specimens

Rectangular specimens with an approximate area of 6.45 cm^2 were prepared by polishing with silicon carbide paper to SiC 600 grit, cleaned in deionised water, degreased in ethanol, dried and stored in plastic bags and placed in a dessicator.

The specimens for corrosion tests were carbon steel, copper, tin, nickel and silver, with exposure periods of 1, 3, 6, 12 and 24 months in an upright position (ASTM G 1, G 4). An aluminum metal cabin, which allows free circulation of air, was built to simulate the conditions of indoor environments (J. Flores et al, 2006) (Figure 10), and installed 10 meters above the ground on the roof of a building. Subsequently the specimens were weighed on an analytical balance.

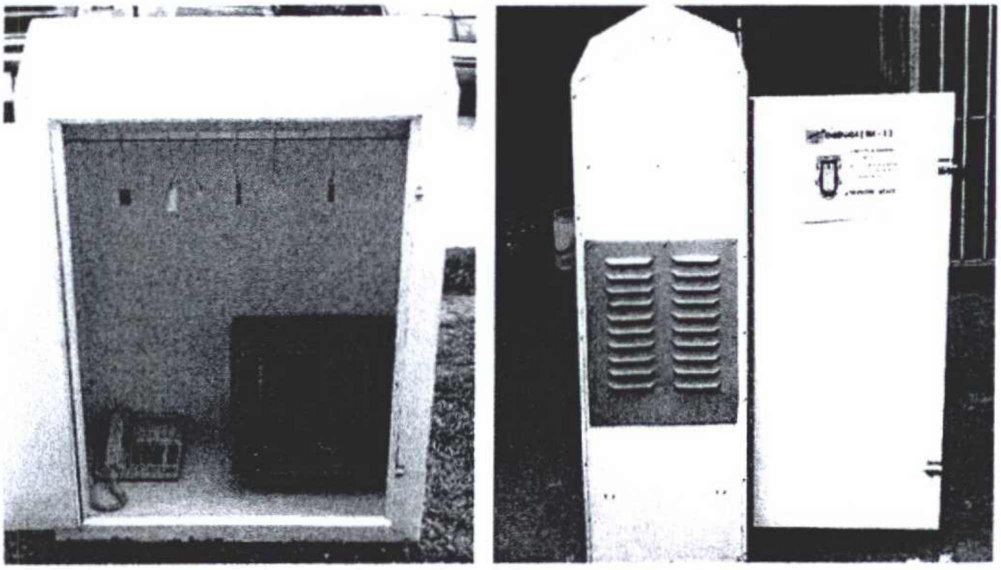


Figure 10. Simulation chamber for corrosion: left. Front view with installed specimens, Right. Side view with the ventilation device.

The classification of the corrosivity categories according to TOW was established following the standards ISO 9223, ISO 9224, ISO 9225, ISO 9226, ISO 1184-1 and ISO 1184-2 (Table 6). The deterioration of the metal specimens was evaluated by the gravimetric method; it was correlated with the minimum, average and maximum RH and outdoor temperature in different seasonal periods, which affect the plants indoor climate.

The electrical properties of a material are at least partially a function of the amount of humidity and pollutants present in the indoor environment, because the corrosive effect increases after moisture and ionic compounds are mixed G. Lopez, et al, 2007).

Categories (a)	TOW (b) h/year
τ_1	≤10
τ_2	10 to 250
τ_3	250 to 2500
τ_4	2500 to 5500
τ_5	> 5500

Source. Environmental Deterioration of Materials, A. Moncmanova, WIT Press, 2007. [a] According to ISO 9223. [b] TOW. time of wetness; RH 80%, Temp > 0° C.

Table 6. Level categories of time of wetness in metals

7.2. Corrosion measurement

To determine the rates of indoor corrosion in the electronics industry and their relationship with outdoor conditions in a desertic region, a comparative measurement was performed exposing samples at indoor conditions and other metallic coupons in a test chamber. ASTM G50 was used to evaluate the corrosion rate in seasonal periods and in different environments (B.G. Lopez et al, 2007). The surfaces of the corroded metals were analyzed by scanning electron microscopy coupled to an electron disperse X-ray analyzer in order to characterize their morphology and chemical composition.

7.3. Gravimetric analysis

The corrosion test specimens were installed for periods of 1, 3, 6, 12 and 24 months and exposed to air pollutants from outside sources. After each exposure period the specimens were removed and weighed to obtain the weight gain due to the corrosion process.

The corrosion products morphology was observed in a optical microscope before being cleaned and reweighed to obtain the mass loss on an analytical balance to the nearest 0.0001 g. The simulation chamber was fabricated with pre-coated aluminum and had a volume of $0.1m^3$ with two air inlets blinds coupled to metallic filters in order to permit the penetration of gases with the flow of air and to prevent the penetration of dust to avoid mistakes in the weightings. The Scanning Electron Microscope (SEM) was used and the chemical composition was determined by Electron Dispersive X-ray (EDS).

7.4. Numerical analysis

MATLAB a numerical computing environment and programming language, which allows easy matrix manipulation, creation of graphs of functions and data, implementation of algorithms, creation of user interfaces between operations and other program in different languages was utilized for the numerical analysis.

The analysis gives the correlation of climatic parameters, environmental and corrosion of metal specimens evaluated in the test chamber and in the companies. The graphics are of three-dimensions, which indicate areas of greater relationship between the variables of weather, air pollutants and corrosion rate, in order to determine the causes of the generation of corrosion in metallic materials used in the electronics industry and suggest methods of protection required to increase their lifetime.

The data were evaluated to determine the relationship between environmental parameters and corrosion rates. Linear regression analyses were performed to get the best fit models for experimental data and the trend of corrosion rate.

7.5. Corrosion of the metals at electronics plants conditions

Several techniques were used to obtain and organize information from the indoor environment, where mainly sulfates and chlorides were monitored and evaluated for TOW with RH levels and temperatures greater than 80% and 0 º C.

In the analysis data of RH higher than 70%, temperatures higher than 35 ºC and air pollutants such as CO, NO_X, O_3 and SO_2, in the periods that overpass the air quality standards in Mexicali, were considered (G. Lopez, 2008). In summer season the corrosion rate increased in the temperature range of 30 ° C to 42 ° C and RH levels of 35% to 65. Moreover, in the winter, with a range of temperature from 2 ° C to 12 º C and RH levels ranging between 35% and 70%, there was a higher incidence of water condensation on the metal surface.

The Figure 11 shows the evaluation of corrosion of copper at 2 ° C to 13 ° C and RH of 34% to 70% indicating that the corrosion rate diminishes. At temperatures of 23 ° C to 30 ° C, with RH levels of 30% and 75%, the corrosion rates increases. This methodology was applied for the corrosion behavior of the other metals tested and the results showed a very good fit in all the cases. Nevertheless, it is necessary to analyze data from several environmental monitoring stations in order to establish a map of the main pollutants behavior by season, zone, climate, economic activities, temperature and RH for at least 5 years. This map must be the most possible closer to the real conditions.

7.6. Corrosivity levels

The main sources of corrosive emissions in Mexicali are cars, fine dust from agricultural fields of an arid zone and the thermal and geothermal power plants (Valdez et al, 2006, J. Flores et al., 2003). Figures 12 and 13 show the corrosion rate values for both simulation chamber and industrial plants tests, it is clear that carbon steel is suffering an accelerated deterioration regarding to silver, copper, tin and nickel, in this order.

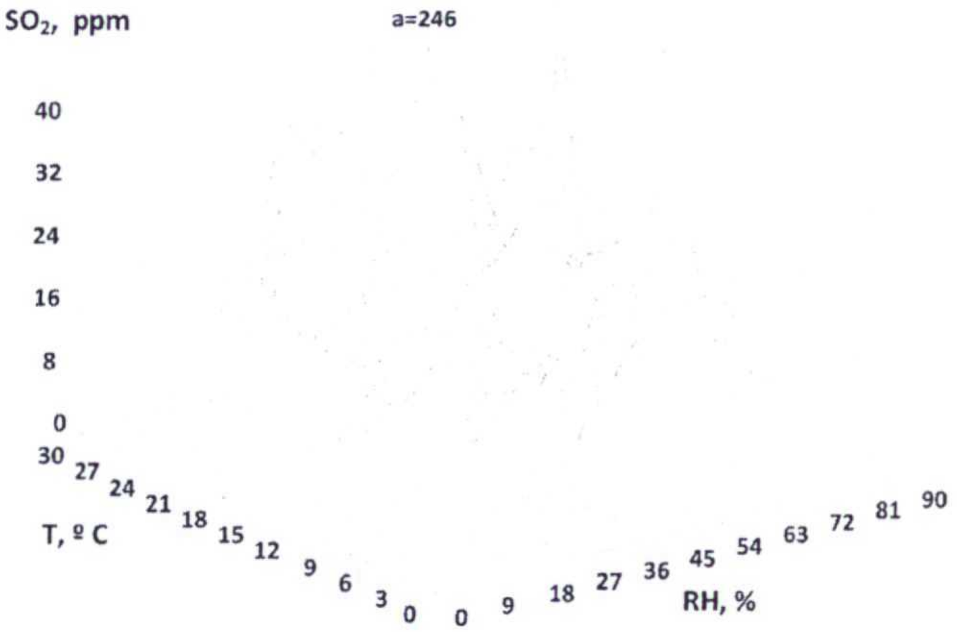


Figure 11. Correlation of temperature, RH and SO_2, a) represents maximum corrosion rate (mg/m^2.year) of copper

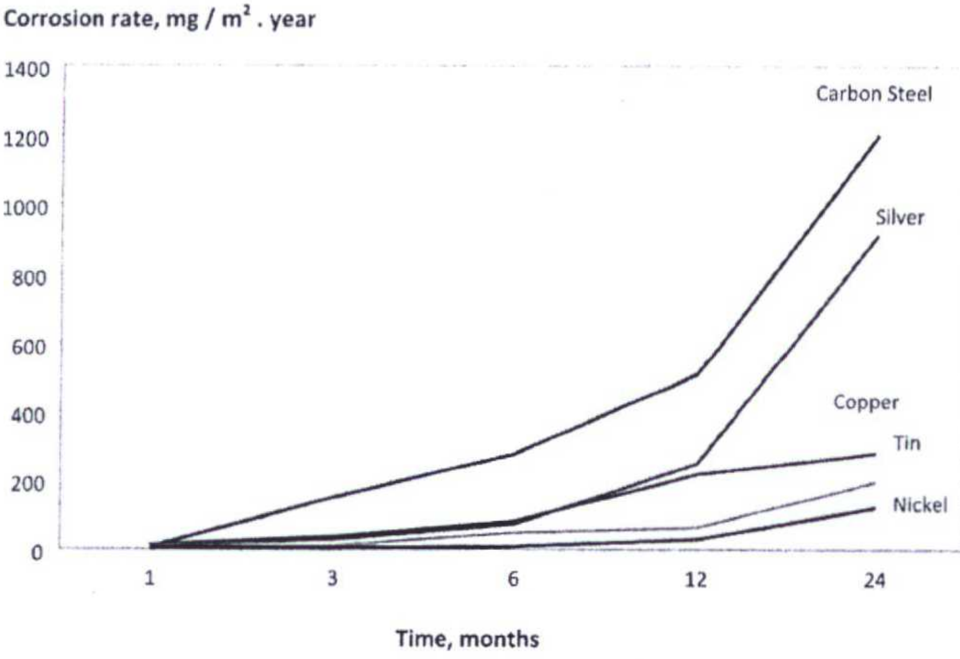


Figure 12. Corrosion rate of metals in the simulation chamber (2003 to 2005)

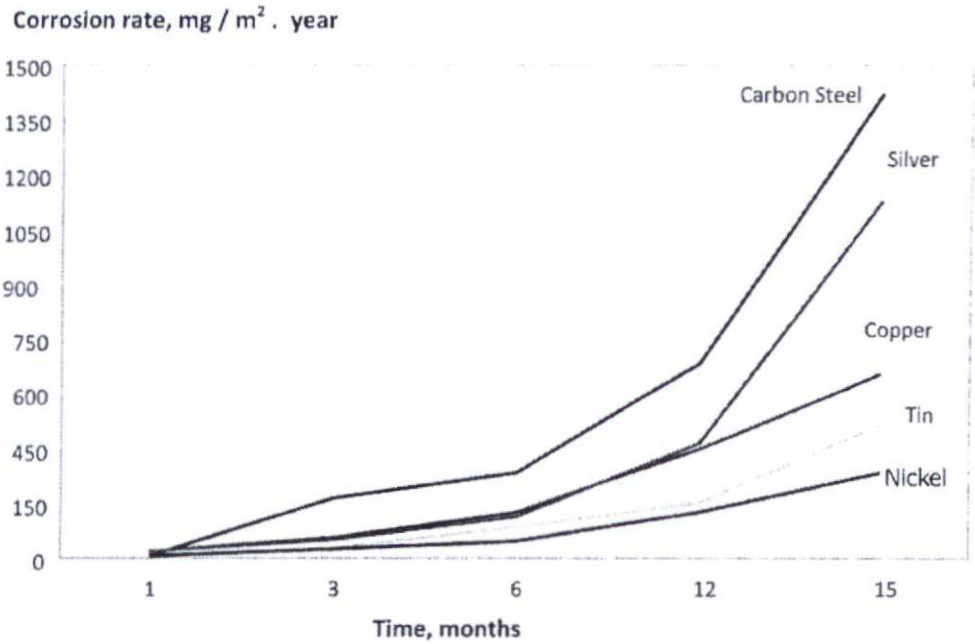


Figure 13. Corrosion rate of metals in industrial plants (2003 to 2005).

The exposure time in the chamber was 24 months and 16 months in the companies. The concentration of several atmospheric pollutants: CO, NO_x, O_3 and SO_2 were monthly recorded by an automatic air pollutants monitoring station that belongs to the California Environmental Protection Agency-CALEPA network.

The electronic instruments used to monitoring air pollutants were equipped with filters to trap and detect gases and particles of air pollutants. To determine the concentration of sulfate in indoor of industrial plants the sulfatation plate technique was used inside industrial plants (ASTM G 91). Sulfates penetrate the plant environment by air currents, cracks, access doors and air conditioning systems that do not have special filters.

The exposure periods at indoor industrial plants conditions were determined according to the aggressiveness of the indoor environment, by day, week and month, seasonal and annual period. The wet candle method is applied to measure the speed of atmospheric deposition of chloride salts in a given area per unit time (ASTM G 140).

The information obtained from the deposition of chloride is used to classify the level of corrosivity of a specific area, such as conditions in the electronics industry. The standard is based in the ISO 9223 with reference to ASTM standards G 91 and G 140, measured in mg/m^2.year. This test is done because the levels of chlorides increase indoor atmospheric corrosion and is an important factor of corrosion phenomena. Sometimes the addition of chloride ions to metallic surfaces generate and increase the corrosion intensity, as in the case of copper and zinc, where these salts do not dissolve easily during corrosion in some areas of the metal causing pitting (Moncmanova et al, 2007).

In the beginning the corrosion rates were low for all the metals, with a variation of the RH from 40% to 60% and temperatures ranging from 25 ºC to 35 ºC (Zlatev et al, 2009). The surface spots presents on the surfaces of carbon steel, copper and silver were indicatives of an incipient corrosion process on these metals.

After 100 days exposure the weather turns warm and the temperature increases in the range from 30 ºC to 40 ºC and RH lower than 70%, the corrosion of copper, carbon steel and silver was pronounced, while nickel remains unaffected (G. Lopez et al, 2009).

The corrosion rate of all the metals was more severe after six month exposure. Ni and Sn show the best behavior compared with carbon steel, copper and silver which are covered with uniform layers of corrosion products. In this period the RH varied between 50% and 75 % and the average range of temperature was 30 ºC to 40 ºC and all the pollutants measured were higher than the permissible concentrations by the air quality standards. After one year the corrosion rate increases rapidly at approximately twice the value of to the previous period.

For specimens exposed during two years, the corrosion rate of copper coupons increases exponentially in a clear activated process. In general, all the metals showed corrosion damage and deterioration of their surfaces by the corrosion process effect. It was confirmed that SO_2 and NO_x were the predominant gaseous air pollutants. Fig. 14 shows the microstructures of corrosion products formed on the copper surface observing the presence of aggregates and pitting; the EDX analysis indicates that the main corrosion product is copper sulphide. Portable hydrogen sulphide monitors were used to measure the concentration of this gas at indoor conditions in different electronics industrial plants and in the interior of the simulation chamber. The H_2S was detected at indoor conditions with concentrations close to 1 ppm and an average value of 0.1 ppm (B.G. Lopez et al, 2007).

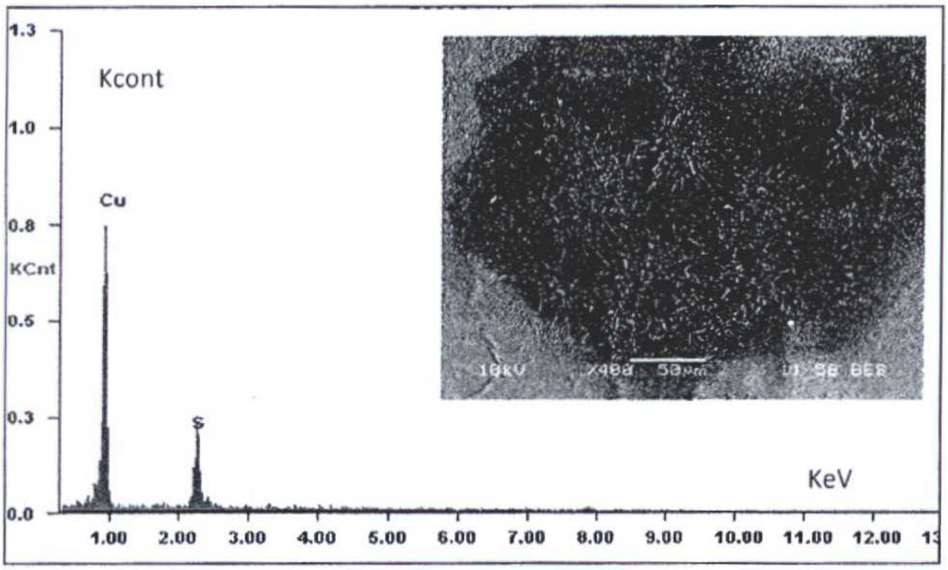


Figure 14. SEM microphotograph of copper after 6 months of exposure at indoors and EDX analysis.

8. Conclusions

All the metals tested used in the manufacturing of electronic devices, were deteriorated by atmospheric corrosion after two years exposure. Sulphide was the main component in the corrosion product layer, due the presence of SO_2 and H_2S produce by human activities and the geothermal field of Cerro Prieto, which promotes the contamination of indoor places.

Carbon steel, copper, nickel, silver and tin exposed to air pollutants reveal that an increase on their concentrations at outdoor conditions has a critical impact on the indoor corrosion process. Long exposure periods with RH values higher than 75 %, and concentrations of pollutants that exceeds those levels established in the regulations, promotes the corrosion of the metals evaluated.

In a descendent order, the most susceptible metals were carbon steel, copper, silver, tin and nickel. The use of 3D plots for multivariable systems generated by the MathLab software represents a useful tool for the monitoring of corrosion at indoor plants conditions. The 3D plots indicate the presence of pollutants in different levels of RH and temperature, and corrosion rates of the metallic probes. These plots and the Mathlab software constitute a very useful tool to study these phenomena.

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