Appendix G

Checklist for Drinking Water Source Assessment – Surface Water Source

Public water system: ______________________________ID No.:________________________

Name of source:___________________________________ID No.:________________________

Assessment date:__________Assessment conducted by__________________________________

The following information should be contained in the drinking water source assessment submittal.

If another report that is the functional equivalent to the drinking water assessment (e.g., Watershed Sanitary Survey) is included in this assessment, the part of that report that fulfills the components of the source water assessment should be clearly indicated.

_______Source name, system name, source and system identification numbers, date of assessment, name of person and/or organization conducting the assessment (Appendix G, this form)

_______Assessment map with source location, source area (watershed), and protection zones (if defined).

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_______Drinking water source location coordinates and accuracy of method used (Appendix A or equivalent)

_______Delineation of protection zones, if applicable (Appendix B or equivalent)

_______Drinking water Physical Barrier Effectiveness Checklist (Appendix C)

_______Possible contaminating activities (PCA) inventory form (Appendix D).

_______Possible contaminating activities evaluation (optional) (Appendix E)

_______Vulnerability ranking (Appendix F)

_______Additional maps (optional) (e.g. local maps of zones and PCAs, recharge area maps, or maps indicating direction of ground water flow)

_______Means of Public Availability of Report (indicate those that will be used)

_______Notice in the annual water quality/consumer confidence report* (minimum)
_______Copy in DHS district office (minimum)
_______Copy in public water system office (recommended)
_______Copy in public library/libraries
_______Internet (indicate Internet address: _________________________)
_______Other (describe)

*The annual report should indicate where customers can review the assessments.

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APPENDICES TO BE USED FOR A GROUND WATER SOURCE

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Appendix H

Drinking Water Source Location – Ground Water

Public water system: ______________________________ID No.:________________________

Name of source:___________________________________ID No.:________________________

Location date:____________ Source located by (name of person):________________________

Method of determining location:

______USGS quad map (7.5 minute series, 1:24,000 scale), hand calculated

______USGS quad map (7.5 minute series, 1:24,000 scale), computer calculated

______Global Positioning System (GPS)

Unit (manufacturer/model): ________________________________

Accuracy of GPS unit (+/- ________ft.)

______Other Method ______________________________

Accuracy of method (+/- _________ft.)

Location of well (decimal degrees): Latitude:___________________________________

Longitude:_________________________________

Physical description of location [Pertinent landmarks, address, or approximate address (cross streets, etc.)]:

General description of recharge area, if known:

NOTE: Indicate location of the well on the drinking water source assessment map. The map should also indicate locations of the source area and protection zones. (See other Appendices).

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Appendix I

Delineation of Ground Water Protection Zones

Public water system: ______________________________ ID No.:________________________

Name of source:___________________________________ ID No.:________________________

Delineation date:______________ Delineation conducted by ______________________________

Indicate the method used to delineate the zones:

______Calculated Fixed Radius (Default) (Show calculations below)

______Modified Calculated Fixed Radius (Show calculations below and attach documentation for direction of ground water flow)

______More detailed methods
Type used (i.e., analytical methods, hydrogeologic mapping, modeling):

______Arbitrary Fixed Radius (For use only by or with permission of DHS—use minimum distances shown below)

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Calculated Fixed Radius Equation

The equation for the calculated fixed radius (R) is $R_t = \sqrt{Q\,t / \pi\,\eta\,H}$

$R_t = R_2$, R_5, or R_{10} corresponding to t (Calculate R for each of three times of travel, TOT)
Q = maximum pumping capacity of well
(ft^3/year = gpm x 70,267):_______________
t = time of travel (years), 2, 5 and 10 years
$\pi = 3.1416$
η = effective porosity (decimal percent) (If unknown, assume 0.2): ___________________

H = screened interval of well (feet) (If unknown, assume 10% of Q gpm, 10 ft minimum): ___________________

Specific methods follow on next page

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Calculated Fixed Radius Delineation Method (Default)

Using the equation presented above, calculate the size of zones for the appropriate aquifer setting of the source.

Porous Media Aquifer

Zone A	(2 year TOT)	R_2 = _______ft, minimum = 600 ft —use larger: ______ft
Zone B5	(5 year TOT)	R_5 = ________ft, minimum = 1,000 ft—use larger: ______ft
Zone B10	(10 year TOT)	R_{10} = ________ft, minimum = 1,500 ft—use larger: ______ft

Fractured Rock Aquifer

(Increase size of zones by 50%)

Zone A	(2 year TOT)	$1.5R_2$ = _______ft, minimum = 900 ft—use larger: ______ft
Zone B5	(5 year TOT)	$1.5R_5$ = ______ft, minimum = 1,500 ft—use larger: ______ft
Zone B10	(10 year TOT)	$1.5R_{10}$ = ______ft, minimum = 2,250 ft—use larger: ______ft

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Modified Calculated Fixed Radius Delineation Method

In porous media aquifers, if the direction of ground water flow is known (see Section 6.2.3), the default zone circle may be shifted upgradient by $0.5R_t$. The upgradient and downgradient limits of the zone are determined below.

Zone A (2-year TOT)

upgradient distance = $1.5R_2$ = ________ft, minimum = 900 ft, use larger: ________ft
downgradient distance = $0.5R_2$ = _________ft, minimum = 300 ft, use larger: ________ft

Zone B5 (5-year TOT)

upgradient distance = $1.5R_5$ = _______ft, minimum = 1,500 ft, use larger: _________ft
downgradient distance = $0.5R_5$ = _______ft, minimum = 500 ft, use larger: __________ft

Zone B10 (10-year TOT)

upgradient distance = $1.5R_{10}$ = ________ft, minimum = 2,250 ft, use larger: ________ft
downgradient distance = $0.5R_{10}$ = ________ft, minimum = 750 ft, use larger: ________ft

Appendix J

Physical Barrier Effectiveness Checklist and Well Data Sheet - Ground Water Source

Public water system: ______________________________ ID No.: ________________________

Name of source: __________________________________ ID No.: ________________________

Assessment date: ______________ Assessment conducted by ______________________________

Complete DHS Well Data Sheet (attached) and include with Assessment submittal.

Directions: Auguscik-25 (Cont.)

1. Read through the form and collect the information needed to complete the form. (Hydrogeology, Soils, Presence of abandoned or improperly destroyed wells, Well construction and operation.)

2. Determine Parameter A, Type of Aquifer.
   - If the aquifer is confined, use the right-hand column, and evaluate only the parameters indicated for confined aquifers.
   - If the aquifer is unconfined, semi-confined, or the degree of confinement is unknown, or if the aquifer is fractured rock, use the left-hand column and evaluate only the parameters for unconfined aquifers.

3. For each parameter appropriate for the source, place a check in the box for the answer that most closely applies to that source. If more than one answer is possible, select the more conservative (i.e., lower points) answer. *[For example, if the depth to static water (Parameter D) has varied between 45 and 55 feet, choose answer 2 (20 to 50 feet).]*

4. Add the points in the column appropriate for the source and interpret the score as shown on the bottom of the last page.
   - Determine whether the source has a High, Moderate or Low Physical Barrier Effectiveness. Use this in the Vulnerability analysis. The higher the points, generally the more effective the source and site are to retarding the movement of contaminants to the water supply.

NOTE: If the source is located in fractured rock the source is considered to have a Low Physical Barrier Effectiveness, regardless of the point total. So, if Parameter B, Aquifer Material is 3, the remainder of the form does not need to be completed.

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Physical Barrier Effectiveness (PBE) – Ground Water, page 1 of 2
Source Name:____________________Source No.:________

PARAMETER	*POINTS* Unconfined		*POINTS* Confined	
A. TYPE OF AQUIFER Confinement *(up to **50** points maximum)* choose one				
a. Unconfined, Semi-confined, Fractured Rock, Unknown	0			
b. Confined			50	
B. AQUIFER MATERIAL (Unconfined Aquifer) Type of materials within the aquifer *(up to **20** points maximum)* choose one				
1. Porous Media (Interbedded sands, silts, clays, gravels) with continuous clay layer minimum 25' thick above water table within Zone A	20			
2. Porous Media (Interbedded sands, silts, clays, and gravels)	10			
3. Fractured rock * (* Low Physical Barrier Effectiveness - no further questions required)	0			
C. PATHWAYS OF CONTAMINATION (All Aquifers) Presence of Abandoned or Improperly Destroyed Wells *(up to **10** points maximum)*				
1. Are they present within Zone A (2-year time of travel (TOT) distance)?				
a. Yes or unknown	0		0	
b. No	5		5	
2. Are they present within Zone B5 (2- to 5-year TOT distance)?				
a. Yes or unknown	0		0	
b. No	3		3	
3. Are they present within Zone B10 (5- to 10-year TOT distance)?				
a. Yes or unknown	0		0	
b. No	2		2	
D. STATIC WATER CONDITIONS (Unconfined Aquifer) Depth to static Water (DTW) = ______ feet *(up to **10** points maximum)* choose one				
1. 0 to 20 feet	0			
2. 20 to 50 feet	2			
3. 50 to 100 feet	6			
4. > 100 feet	10			
E. WELL OPERATION (Unconfined Aquifer) Depth to Uppermost Perforations (DUP) DUP = ______ feet Maximum Pumping Rate of Well (Q) Q = ______ gallons/minute Length of screened interval (H) H = ______ feet				
[(DUP – DTW) / (Q/H)] = *(up to **10** points maximum)* choose one				
1. < 5	0			
2. 5 to 10	5			
3. > 10	10			

Physical Barrier Effectiveness – Ground Water, page 2 of 2

Source Name:________________________________Source No.____________________________

PARAMETER	*POINTS* Unconfined		*POINTS* Confined	
F. HYDRAULIC HEAD (Confined Aquifer) What is the relationship in hydraulic head between the confined aquifer and the overlying unconfined aquifer? (i.e., does the well flow under artesian conditions?) *(up to* ***20*** *points maximum)* choose one				
1. head in confined aquifer is higher than head in unconfined aquifer <u>under all conditions</u>			20	
2. head in confined aquifer is higher than head in unconfined aquifer <u>under static conditions</u>			10	
3. head in confined aquifer is lower than or same as head in unconfined aquifer			0	
4. unknown			0	
G. WELL CONSTRUCTION (All Aquifers) 1. Sanitary Seal (Annular Seal) Depth = ______ feet *(up to* ***10*** *points maximum)* choose one				
a. None or less than 20 feet deep	0		0	
b. 20 to 50 ft deep	6		10	
c. 50 ft or greater	10		10	
2. Surface seal (concrete cap) *(up to* ***4*** *points maximum)* choose one				
a. Not present or improperly constructed	0		0	
b. Watertight, slopes away from well, at least 2' laterally in all directions	4		4	
3. Flooding potential at well site *(up to* ***1*** *point maximum)* choose one				
a. Subject to localized flooding (i.e. in low area or unsealed pit or vault) or Within 100 year flood plain	0		0	
b. Not subject to flooding	1		1	
4. Security at well site *(up to* ***5*** *points maximum)* choose one				
a. Not secure	0		0	
b. Secure (i.e. housing, fencing, etc.)	5		5	
Maximum Points Possible	70		100	
POINT TOTAL FOR THIS SOURCE				

Physical Barrier Effectiveness SCORE INTERPRETATION

<u>Point Total</u>		**<u>Effectiveness</u>**	
______**0 to 35**	=	**Low**	(includes all sources in Fractured Rock)
______**36 to 69**	=	**Moderate**	
______**70 to 100**	=	**High**	

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California Drinking Water Source Assessment and Protection Program

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WELL DATA SHEET (Sheet 1 of 3)

Complete as much information as possible. Leave blank if information is not available, use N.A. if not applicable.
** Indicates items required for Source Water Assessment* *** Indicates additional items required for Ground Water Rule*

		Actual or Estimated?
DATA SHEET GENERAL INFORMATION		
System Name		
System Number		
Source of Information *(See Note 1)*		
Personnel Collecting Information		
Date		
WELL IDENTIFICATION		
* Well Number or Name		
* DHS Source Identification Number (FRDS ID No.)		
DWR Well Log on File? (yes or no)		
State Well Number (from DWR)		
Well Status (Active, Standby, Inactive)		
Date of Inactive Status (if applicable)		
WELL LOCATION		
Latitude		
Longitude		
Elevation		
Street Address		
* Neighborhood/Surrounding Area *(see Note 2)*		
Site plan on file? (yes or no)		
DWR Ground Water Basin		
DWR Ground Water Sub-basin		
SANITARY CONDITIONS		
** Distance to: Sewer Line, Sewage Disposal, or Septic tank		
Distance to: Other sanitary concerns		
Distance to: Other Wells (Active)		
Distance to: Other Wells (Abandoned)		
** Size of controlled area around well (square feet)		
* Type of access control to well site *(See Note 3)*		
* Surface Seal? (Concrete slab) (yes or no)		
* Dimensions of concrete surface slab (ft)		
* Within 100 year flood plain? (yes or no)		
* Drainage away from well? (yes or no)		
ENCLOSURE/HOUSING		
Type		
Condition		
Pit depth (if applicable)		
Pit Drained? (if applicable)		
Floor (material)		

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WELL DATA SHEET (Sheet 2 of 3)

WELL CONSTRUCTION		Actual or Estimated?
Date drilled		
Drilling Method		
Depth of Bore Hole (feet below ground surface)		
Casing Depth (feet below ground surface)		
Casing Diameter (inches)		
Casing Material		
Additional casing depth (if applicable)		
Additional casing diameter (if applicable)		
Additional casing material (if applicable)		
Conductor casing used? (yes or no) *(See Note 4)*		
Conductor casing removed? (yes or no)		
* Depth to highest perforations/screens(ft below surface)		
Depth(s) and Length(s) of screened interval(s)		
* Total length of screened interval		
* Annular Seal? (yes, no, or not sure) *(See Note 5)*		
* Depth of Annular Seal (ft)		
Material of Annular Seal (cement grout, bentonite, etc.)		
Gravel pack, Depth to top (ft below ground surface)		
Total length of gravel pack (ft)		
AQUIFER		
* Aquifer Materials *(See Note 6)*		
* Confining layer (impervious strata) above aquifer? (yes, no or not sure)		
Thickness of confining layer, if known (ft)		
Depth to confining layer, if known (ft below ground)		
Sanitary Seal terminates in impervious strata? (yes or no)		
* Static water level (ft below ground surface)		
Pumping water level (ft below ground surface)		
Date water level measured		
WELL PRODUCTION		
Well Yield (gpm)		
Well Yield Based On (i.e., pump test, etc.)		
Date measured		
Production (gallons per year)		
Frequency of Use (hours/year)		
Typical pumping duration (hours/day)		
PUMP		
Make		
Type		
Size (hp)		
* Capacity (gpm)		
Depth to suction intake (ft below ground surface)		

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California Drinking Water Source Assessment and Protection Program

WELL DATA SHEET (Sheet 3 of 3)

		Actual or Estimated?
Lubrication Type		
Type of Power: (i.e., electric, diesel, etc.)		
Auxiliary power available? (yes or no)		
Operation controlled by: *(See Note 7)*		
Pump to Waste capability? (yes or no)		
Discharges to: (i.e., distribution system, storage, etc.)		

(Use or note these items as appropriate)

Raw Water Quality concerns? (coliform, chemicals, other)

Continuous Chlorination provided?

Pitless Adapter? Make and Model

Height of pump base (inches)

Casing Vent? (yes or no)

Air/Vacuum Release? (yes or no)

Sampling Taps? (yes or no)

Location of sampling taps

Wellhead Riser? (yes or no) height above well

NOTES

1. Sources of information: well log, DHS or County files, system files, personnel, etc.

2. Neighborhood/Surrounding Area (list all that apply):
   A= Agricultural, Ru = Rural, Re = Residential,
   Co = Commercial, I = Industrial, Mu = Municipal,
   P = Pristine, O = Other

3. Access Control: fencing, building, etc.

4. Annular Seal - Seal of grout in the space between the well casing and the wall of the drilled hole. Sometimes called "sanitary seal".

5. Conductor Casing - Oversized casing used to stabilize bore hole during well construction. Usually removed during installation of annular seal.

6. Aquifer materials (list all that apply): sands, silts, clays, gravel, rocks, fractured rock

7. Operation controlled by: level in tank, system demand, pressure, etc.

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Appendix K

Possible Contaminating Activity (PCA) Inventory Form

Ground Water Source

Public water system name:________________________________ID No.__________________

Name of drinking water source:____________________________ID No.__________________

Inventory date:______________________ Inventory conducted by:________________________

Indicate PCAs pertinent to the drinking water source, its source area and protection zones, from the following tables, as applicable:

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Commercial/Industrial (Table K-1) ______

Residential/Municipal (Table K-2) ______

Agricultural/Rural (Table K-3) ______

Other (required for all) (Table K-4) ______

Is this for a ground water recharge area? YES/NO __________ (If YES, also use Appendix D, Tables D-1 through D-4, as appropriate)

Attach map of Drinking Water Source with Zones A, B5 and B10 indicated, and buffer zones (if defined).

Proceed to appropriate checklist or checklists. Place a mark in the appropriate boxes.
Example:

		X

Risk Ranking of PCAs (see Tables 7-2, 7-3, 7-4 and 7-5 for separate category lists), where VH = Very High Risk, H = High Risk, M = Moderate Risk, L = Low Risk

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PCA Checklist Table K-1, page 1 of 2						
COMMERCIAL/INDUSTRIAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Automobile-related activities						
Body shops (H)						
Car washes (M)						
Gas stations (VH)						
Repair shops (H)						
Boat services/repair/ refinishing (H)						
Chemical/petroleum processing/storage (VH)						
Chemical/petroleum pipelines (H)						
Dry cleaners (VH)						
Electrical/electronic manufacturing (H)						
Fleet/truck/bus terminals (H)						
Furniture repair/ manufacturing (H)						
Home manufacturing (H)						
Junk/scrap/salvage yards (H)						
Machine shops (H)						
Metal plating/ finishing/fabricating (VH)						
Photo processing/printing (H)						
Plastics/synthetics producers (VH)						
Research laboratories (H)						

PCA Checklist Table K-1, page 2 of 2						
COMMERCIAL/INDUSTRIAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Wood preserving/treating (H)						
Wood/pulp/paper processing and mills (H)						
Lumber processing and manufacturing (H)						
Sewer collection systems (H, if in Zone A, otherwise L)						
Parking lots/malls (>50 spaces) (M)						
Cement/concrete plants (M)						
Food processing (M)						
Funeral services/graveyards (M)						
Hardware/lumber/parts stores (M)						
Appliance/Electronic Repair (L)						
Office buildings/complexes (L)						
Rental Yards (L)						
RV/mini storage (L)						
Other (list)						

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PCA Checklist Table K-2, page 1 of 2						
RESIDENTIAL/MUNICIPAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Airports - Maintenance/ fueling areas (VH)						
Landfills/dumps (VH)						
Railroad yards/ maintenance/ fueling areas (H)						
Septic systems - high density (>1/acre) (VH if in Zone A, otherwise M)						
Sewer collection systems (H, if in Zone A, otherwise L)						
Utility stations - maintenance areas (H)						
Wastewater treatment and disposal facilities (VH in Zone A, otherwise H)						
Drinking water treatment plants (M)						
Golf courses (M)						
Housing - high density (>1 house/0.5 acres) (M)						
Motor pools (M)						
Parks (M)						
Waste transfer/recycling stations (M)						

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PCA Checklist Table K-2, page 2 of 2 RESIDENTIAL/MUNICIPAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Apartments and condominiums (L)						
Campgrounds/ Recreational areas (L)						
Fire stations (L)						
RV Parks (L)						
Schools (L)						
Hotels, Motels (L)						
Other (list)						

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PCA Checklist Table K-3, page 1of 2						
AGRICULTURAL/RURAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Grazing (> 5 large animals or equivalent per acre) (H in Zone A, otherwise M)						
Concentrated Animal Feeding Operations (CAFOs) as defined in federal regulation[1] (VH in Zone A, otherwise H)						
Animal Feeding Operations as defined in federal regulation[2] (VH in Zone A, otherwise H)						
Other Animal operations (H in Zone A, otherwise M)						
Farm chemical distributor/ application service (H)						
Farm machinery repair (H)						
Septic systems – low density (<1/acre) (H in Zone A, otherwise L)						
Lagoons / liquid wastes (H)						
Machine shops (H)						
Pesticide/fertilizer/ petroleum storage & transfer areas (H)						
Agricultural Drainage (H in Zone A, otherwise M)						
Wells - Agricultural/ Irrigation (H)						

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PCA Checklist Table K-3, page 2 of 2 AGRICULTURAL/RURAL						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Managed Forests (M)						
Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetable) (M)						
Fertilizer, Pesticide/ Herbicide Application (M)						
Sewage sludge/biosolids application (M)						
Crops, nonirrigated (e.g., Christmas trees, grains, grass seeds, hay, pasture) (L) (includes drip-irrigated crops)						
Other (list)						

3. Concentrated Animal Feeding Operation: Animal Feeding Operation (requires NPDES permit) with greater than:

If pollutants discharged (directly or indirectly) to navigable waters	**If pollutants not discharged**
300 slaughter or feeder cattle	1,000 slaughter or feeder cattle
200 mature dairy cows	700 mature dairy cows
750 swine	2500 swine
150 horses	500 horses
3000 sheep or lambs	10,000 sheep or lambs
16,500 turkeys	55,000 turkeys
9,000 laying hens or broilers (liquid manure system)	30,000 laying hens or broilers (liquid manure system)
1500 ducks	5000 ducks
300 animal units	1000 animal units

4. Animal Feeding Operation: lot or facility where animals (other than aquatic) have been or will be stabled or confined and fed or maintained for total of 45 days or more in any 12 month period.

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PCA Checklist Table K-4, page 1 of 3						
OTHER ACTIVITIES						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
NPDES/WDR permitted discharges (H)						
Underground Injection of Commercial/Industrial Discharges (VH)						
Historic gas stations (VH)						
Historic waste dumps/ landfills (VH)						
Illegal activities/ unauthorized dumping (H)						
Injection wells/ dry wells/ sumps (VH)						
Known Contaminant Plumes (VH)						
Military installations (VH)						
Mining operations - Historic (VH)						
Mining operations – Active (VH)						
Mining - Sand/Gravel (H)						
Wells – Oil, Gas, Geothermal (H)						
Salt Water Intrusion (H)						
Recreational area— surface water source (H)						

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PCA Checklist Table K-4 , page 2 of 3						
OTHER ACTIVITIES						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Underground storage tanks						
Confirmed leaking tanks (VH)						
Decommissioned - inactive tanks (L)						
Non-regulated tanks (tanks smaller than regulatory limit) (H)						
Not yet upgraded or registered tanks (H)						
Upgraded and/or registered - active tanks (L)						
Above ground storage tanks (M)						
Wells – Water supply (M)						
Construction/demolition staging areas (M)						
Contractor or government agency equipment storage yards (M)						
Dredging (M)						
Transportation corridors						
Freeways/state highways (M)						
Railroads (M)						
Historic railroad right-of-ways (M)						
Road Right-of-ways (herbicide use areas) (M)						
Roads/ Streets (L)						
PCA Checklist **Table K-4, page 3 of 3**						

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OTHER ACTIVITIES						
PCA (Risk Ranking)	No PCA in zones	PCA in Zone A?	PCA in Zone B5?	PCA in Zone B10?	Unknown	Comments
Hospitals (M)						
Storm Drain Discharge Points (M)						
Storm Water Detention Facilities (M)						
Artificial Recharge Projects						
Injection wells (potable water) (L)						
Injection wells (non-potable water) (M)						
Spreading Basins (potable water) (L)						
Spreading Basins (non-potable water) (M)						
Medical/dental offices/clinics (L)						
Veterinary offices/clinics (L)						
Surface water - streams/ lakes/rivers (L)						
Wells – monitoring, test holes (L)						
Other (list)						

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Appendix L

Possible Contaminating Activities Evaluation– Ground Water Source

(Note: This form is OPTIONAL. It should be completed for each PCA if a modification of the risk ranking of a PCA is desired)

Public water system ______________________________ID No. __________ ______

Name of source ________________________________ID No. ______________

Assessment date:____________ Assessment conducted by ______________________

PCA/Potential Contaminant Information

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1. Type of Activity (from the PCA contaminant inventory checklist):

2. Type of potential contaminant associated with this activity (Refer Table 7-2):
   a. Microbiological
   b. Chemical
   c. Both or Other

3. Potential Risk (from PCA contaminant inventory checklist):
   a. Low
   b. Medium
   c. High
   d. Very High

4. Location:
   a. Zone A
   b. Zone B5
   c. Zone B10

5. Spatial Area occupied by activity as percentage of Zone:
   a. Small (<1% of area)
   b. Moderate (1% to 10% of area)
   c. High (>10% of area)
   d. Unknown

6. Volume of potential contaminant *(not applicable for microbiological contaminants)*:
   If the maximum quantity of potential contaminant stored at the facility were discharged into

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the quantity of water produced by the drinking water supply in a day would the concentration be:
a. Small (less than one part per billion)
b. Moderate (between one part per thousand and one part per billion)
c. High (more than one part per thousand)
d. Unknown

7. Magnitude of potential acute or chronic health effects associated with the contaminant:
   a. Low
   b. High
   c. Unknown

8. Likelihood of potential contaminant to migrate to drinking water supply:
   a. Low
   b. High
   c. Unknown

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9. Has the potential contaminant been detected in the drinking water supply or near-by monitoring wells?
   a. Yes
   b. No
   c. Unknown

10. Compliance of facility (demonstrated performance to keep potential contaminant from being discharged)
   a. Good
   b. Poor
   c. Unknown

Determination of revised risk ranking for PCAs

Microbiological Contamination

NOTE: In fractured rock aquifers, microbiological PCAs are always high risk, regardless of the zone, and cannot be modified.

If the PCA is categorized as **2a or 2c**, the risk ranking would be LOW if the PCA meets all of the parameters in the table below for **Low.** The risk ranking would be HIGH if the PCA meets all of the parameters in the table for **High**. Otherwise the risk ranking is MODERATE.

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Microbiological Contamination
PCA Risk Ranking

Parameter	Low	High
3	**a or b**	**c or d**
4	**b or c**	**a**
5	**a**	**c or d**
7	**a**	**b or c**
8	**a**	**b or c**
9	**b**	**a or c**
10	**a**	**b or c**

Chemical Contamination

If the PCA is categorized as **2b or 2c**, the risk ranking would be LOW if the PCA meets all of the parameters in the table below for **Low.** The risk ranking would be HIGH if the PCA meets all of the parameters in the table for **High**. Otherwise the risk ranking is MODERATE.

Chemical Contamination
PCA Risk Ranking

Parameter	Low	High
3	**a or b**	**c or d**
4	**c**	**a or b or c**
5	**a**	**c or d**
6	**a**	**c or d**
7	**a**	**b or c**
8	**a**	**b or c**
9	**b**	**a or c**
10	**a**	**b or c**

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Appendix M

Vulnerability Analysis Procedures – Ground Water Source

The Vulnerability analysis incorporates the types of Possible Contaminating Activities (PCAs) identified in the inventory, their respective Risk Rankings, the Zone and the Physical Barrier Effectiveness determination. These factors are used to develop a prioritized listing of types of PCAs and to determine the types of PCAs to which the drinking water source is most vulnerable.

Public water system: ______________________ID No.:______________

Name of source:__________________________ID No.:______________

Assessment date:__________ Assessment conducted by ________________

Vulnerability analysis steps:

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1. For each type of PCA identified as existing in the protection zones, or as unknown, determine the number of PCA risk ranking points for that type of PCA. (If the risk ranking for a type of PCA has been modified, Appendix L should be attached). (*For example, Very High (VH) risk activities are 7 points.)*

2. For each type of PCA determine the zone in which it occurs. Add the points associated with that zone to the PCA risk ranking points. If the type of PCA exists within more than one zone, repeat the process for each zone. (*For example, if a type of PCA exists in Zone A add 5 points. For a VH risk PCA in Zone A, the PCA Risk Ranking points + Zone points = 7 + 5 = 12 points.*)

3. Determine the Physical Barrier Effectiveness (PBE) for the drinking water source (from Appendix J). Add the points associated with that PBE to the PCA risk ranking and zone points. The total is the Vulnerability Score. (*For example, if the PBE is Low add 5 points. For a VH risk PCA in Zone A, the Vulnerability Score = PCA Risk Ranking points + Zone points + PBE points = 7 + 5 + 5 = 17 points.)*

4. Prioritize all types of PCAs by the Vulnerability Score, from the most points to the least. A sample form is shown below.

5. The drinking water source is vulnerable to all types of PCAs with a Vulnerability Score of **8** or greater. Refer to the Vulnerability Matrix below. The source is <u>most</u> vulnerable to the types of PCAs with the highest score.

6. **In addition, the Drinking Water Source is <u>most</u> vulnerable to all types of PCAs associated with a contaminant detected in the water source, regardless of Vulnerability Score.**

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Vulnerability Matrix for GROUND WATER SOURCES

The cutoff point for vulnerability is **8**. The drinking water source is considered Vulnerable to all PCAs with Vulnerability Score greater than or equal to **8** (shaded boxes).

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PCA points	**Zone points**	**PCA + Zone points**	**PBE Points**			**Vulnerability Score PCA + Zone + PBE points**		
Risk Ranking	A, B5, B10		Low	Mod	High	PBE Low	PBE Mod	PBE High
VH (7)	A (5)	12	5	3	1	17	15	13
VH (7)	B5 (3)	10	5	3	1	15	13	11
VH (7)	B10 (1)	8	5	3	1	13	11	9
VH (7)	Unknown (0) *	7	5	3	1	12	10	8
H (5)	A (5)	10	5	3	1	15	13	11
H (5)	B5 (3)	8	5	3	1	13	11	9
H (5)	B10 (1)	6	5	3	1	11	9	7
H (5)	Unknown (0) *	5	5	3	1	10	8	6
M (3)	A (5)	8	5	3	1	13	11	9
M (3)	B5 (3)	6	5	3	1	11	9	7
M (3)	B10 (1)	4	5	3	1	9	7	5
M (3)	Unknown (0) *	3	5	3	1	8	6	4
L (1)	A (5)	6	5	3	1	11	9	7
L (1)	B5 (3)	4	5	3	1	9	7	5
L (1)	B10 (1)	2	5	3	1	7	5	1
L (1)	Unknown (0) *	1	5	3	1	6	4	2

* Source is considered vulnerable to types of PCAs that are Unknown, if the Vulnerability Score is 8 or higher.

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Format for Prioritized Listing of PCAs
List types of PCAs in order by Vulnerability Score from highest to lowest.

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Zone	Type of PCA	PCA Points VH = 7 H = 5 M = 3 L = 1	Zone Points A = 5 B5 = 3 B10 = 1 Unknown = 0	PBE Points L = 5 M = 3 H = 1	Vulnerability Score PCA points + Zone points + PBE points

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Appendix N
Checklist for Drinking Water Source Assessment – Ground Water Source

Public water system: ______________________________ ID No.:________________________

Name of source:___________________________________ ID No.:________________________

Assessment date:__________Assessment conducted by________________________________

The following information should be contained in the drinking water source assessment submittal.

If another report that is the functional equivalent to the drinking water assessment (e.g., parts of a Ground Water Management Plan) is included in this assessment, the part of that report that fulfills the components of the source water assessment should be clearly indicated.

_______Source name, system name, source and system identification numbers, date of assessment, name of person and/or organization conducting the assessment (Appendix N, this form) Auguscik-25 (Cont.)

_______Assessment map with source location, source area (if known), and protection zones

_______Drinking water source location coordinates and accuracy of method used (Appendix H or equivalent)

_______Delineation of protection zones (Appendix I or equivalent)

_______Drinking water Physical Barrier Effectiveness Checklist (Appendix J)

_______Well Data Sheet

_______Possible contaminating activity (PCA) inventory form (Appendix K)

_______Possible contaminating activities evaluation (optional) (Appendix L)

_______Vulnerability ranking (Appendix M)

_______Additional maps (optional) (e.g., local maps of zones and PCAs, recharge area maps, or maps indicating direction of ground water flow)

_______Means of Public Availability of Report (indicate those that will be used)

_______Notice in the annual consumer confidence report* (minimum)
_______Copy in DHS district office (minimum)
_______Copy in public water system office (recommended)
_______Copy in public library/libraries
_______Internet (indicate Internet address: __________________________)
_______Other (describe)

*The annual report should indicate where customers can review the assessments.

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VEHICLE NOISE STUDY -- FINAL REPORT

PREPARED FOR

WASHINGTON STATE HIGHWAY COMMISSION

DEPARTMENT OF HIGHWAYS

UNDER GRANT AGREEMENT Y-1460

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(Cont.)

BY

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ABSTRACT

This study was made to obtain information on the noise levels being emitted by vehicles currently using the highways of the State of Washington. The Washington State Highway Commission requested this study for guidance in proposing vehicle noise control legislation. The main controversy in states with existing comprehensive vehicle noise legislation has concerned trucks traveling on roads with posted speeds above 35 mph. The main thrust of our study is therefore concerned with this particular area, although data were also taken on automobiles and on roads posted at less than 35 mph. This study is unique in that the noise level and the speed of all vehicles were measured. In addition, all trucks over 10,000 lb were weighed. Our large body of data has been graphed in numerous ways to illustrate various aspects--including how the noise factor varies with speed, weight, and percentage of full load, etc. Some photographs of the trucks together with their noise data are also included.

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SUMMARY

The purpose of this study was to obtain factual information on the noise levels being emitted by vehicles currently using the highways of the State of Washington. This study was requested by the Washington State Highway Commission to help it make rational and meaningful recommendations to the Legislature for enactment of vehicle noise control legislation. Its desire is to set noise limits as low as possible without placing an unreasonable or technically impossible standard on vehicles in this State.

The most comprehensive legislation on this subject has been enacted by the State of California. (Excerpts from their legislation are given in Appendix F.) The California controls which have generated the most controversy are for trucks operating on freeways and other roadways with posted speeds above 35 mph. The main thrust of our study is therefore concerned with this particular area, although data were also taken on automobiles and on roadways posted at less than 35 mph.

Cumulative frequency curves of truck traffic on highways have been made before in other states, e.g., California. However, these studies have not been sufficiently comprehensive to give specific information on how trucks as noise sources contributed to these data. Thus it has not been possible to predict the effect of a stated number of decibels (dB)* in a proposed piece of legislation on any particular segment of the trucking industry.

In our study the trucks were recorded on audio/video tape so that data could be checked and rechecked in the laboratory. A large amount of data was taken on each of the 1,433 trucks in the survey. This included the noise level of the truck on the dBA and dBB scales (see Appendix H for definitions of dB terms), the actual speed as measured on a Doppler-shift radar, the class of the truck, licensed maximum gross weight, measured gross weight, the grade of the roadway on which the vehicle was traveling, and other criteria. The measurements were made at four different sites.

This large body of data has been graphed in various ways in order to illustrate various aspects--including how the noise factor varies with the speed, weight, and percentage of full load. Some photographs of the trucks together with the noise data are also included.

One statement often made by the trucking industry in regard to proposed noise levels derived from cumulative distribution curves is that the trucks on the quiet end of the curve are the small ones or those traveling at low speeds, whereas the other end of the curve contains all the big heavy trucks which are going at full legal speed. Thus, they

*As defined in Appendix H.

fear that noise legislation would wipe out the heavy truck transport industry because it would be technologically impossible to quiet these trucks sufficiently. This report sheds some light on this problem. For example, one of the curves presented is a cumulative distribution curve limited entirely to vehicles which had measured weights over 30,000 lb and which were traveling at more than 50 mph. There were 344 trucks in this category, making a good statistical sample. This curve, Fig. 37, shows that 50% of the trucks in this category were quieter than the present California limit of 90 dBA. It also shows that 2%, or about seven trucks, were actually quieter than 84 dBA. From this information it is obvious that it is technologically possible for heavy, full-speed trucks to be fairly quiet (84 dBA or less).

In general, the data show that the noise level does increase with truck weight and speed. However, the range of variability is great, showing that other factors have a strong influence on the noise output. The plot of noise versus percentage of full load shows almost no correlation. In other words, it is the total weight of the vehicle and not the percentage of the load that counts. The data also show that many trucks would still be very noisy even if all of their low-frequency noise were removed by improved mufflers. Putting an adequate muffler on a truck is not necessarily going to solve that vehicle's noise-emitting problem.

Included in the report are cumulative noise curves for automobiles as well as curves of automobile noise versus speed. Also included are the results of our survey of existing noise legislation (1971) for the U.S. and the Canadian provinces, and a survey of muffler manufacturers and their catalog literature.

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SURVEY TECHNIQUE

Figure 1 is a block diagram of the system used for gathering the data in the field. Basically, the information was recorded on a tape recorder having one video and two audio channels. The General Radio microphone and 20 dB preamplifier were located 50 ft from the center line of the curb lane of the highway under test. The sound information from this was brought back via cable to a van truck in which the recorder and instrumentation were situated. A control box in the van contained an adjustable attenuator so that the dynamic range of the recorder could be placed optimally with respect to the expected noise levels to be measured. This box also contained a carefully calibrated and amplitude-stabilized 1 kHz oscillator. This oscillator was switched on frequently (when there was no truck or automobile of interest on the road) to allow an independent calibration of the system; this signal injected a voltage equivalent to a 90 dB sound signal. In addition, several times during any one tape a General Radio type 1562A sound level calibrator was slipped over the measuring microphone to form a 1 kHz calibration throughout the entire system. Each time the sound calibrator was used it was first coupled to the microphone and then turned on. This allowed the recording to include the warmup period of the acoustic calibrator; whereas when the stabilized oscillator was turned on momentarily for the calibration, no warmup was involved. From the presence or absence of the characteristic warmup signal it was obvious which type of calibration was taking place.

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The audio/video tape recorded data for slightly over one hour. Full acoustic calibration was carried out three times during this period with the local stabilized oscillator calibration taking place with even greater frequency. This information was recorded on audio channel "A" of the tape recorder. A voice microphone was connected to audio channel "B" and was used for giving a running commentary on the traffic passing by at the time the measurements were being taken. This included comments on the type, make, class, and size of truck, as well as lettering, color, size, etc., so the vehicle could be positively identified when it stopped at the weighing station and had other measurements made. This information was complementary to the video channel data which was directly recorded.

The video camera had a view of the roadway immediately in front of the measuring microphone so that in later analysis one could ascertain which vehicle was being measured, and that the accuracy of the data was not clouded in any way by the presence of other vehicles in other lanes. By listening to the recorded sound while watching the vido tape, one could tell that the truck driver had not, for example, suddenly let up on his throttle at the moment of recording. Also in the field-of-view of the video camera were a 24-hr clock, a sign with the date, and a radar speedometer. The speedometer read from 0 to 100 mph full-scale. Having all of these audio and video data in "raw" form on the tape is very important when looking for extrema such as very loud or very quiet trucks. Some errors are bound to creep in when handling large quantities of data, but having it all on tape provided a check on the data points which were of the greatest interest.

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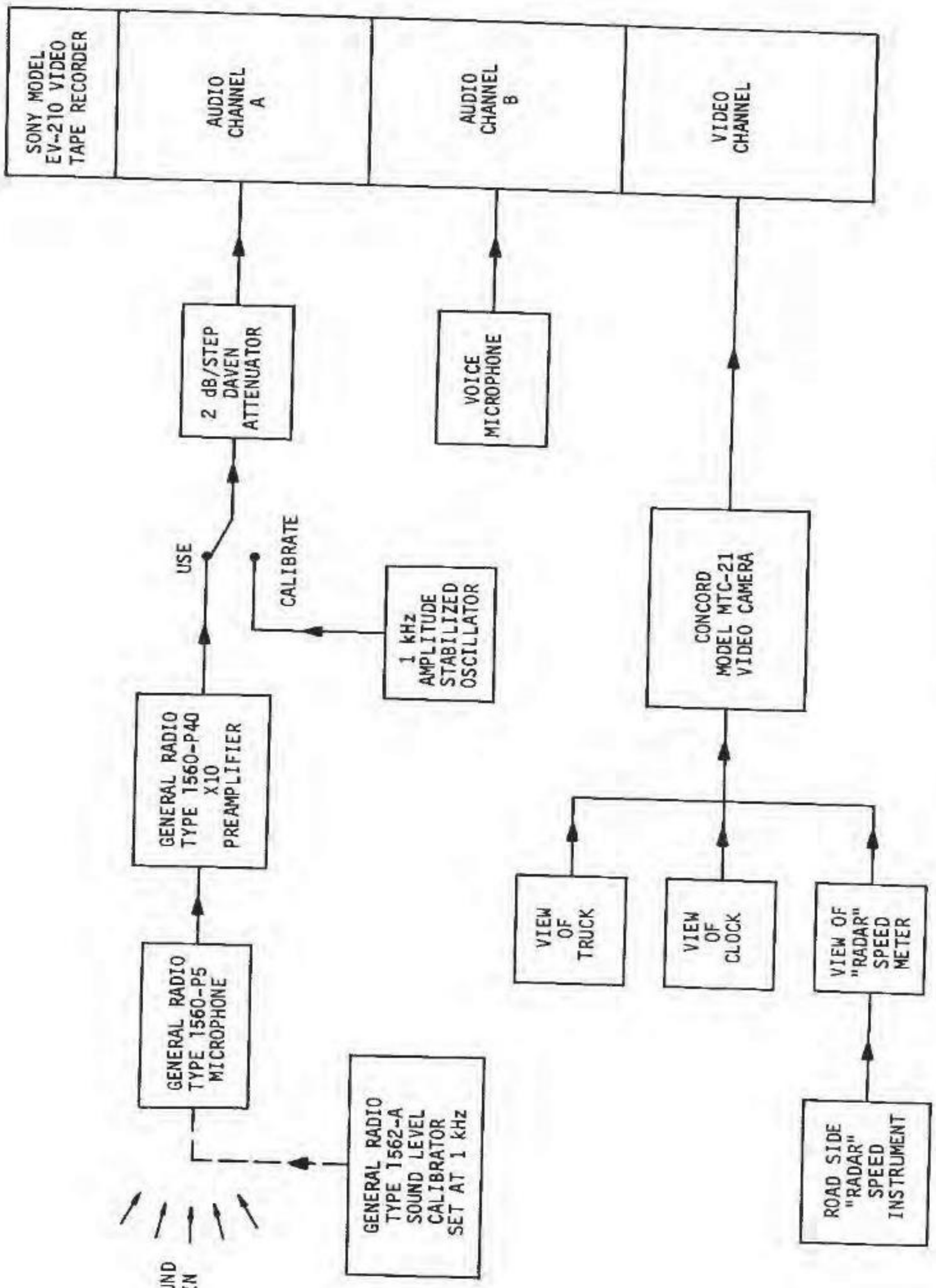

FIGURE 1. BLOCK DIAGRAM OF FIELD DATA GATHERING.

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After passing the video and acoustic recording site, the trucks stopped at a Washington State Patrol weighing station. At the weighing station the license number and licensed gross wieght were recorded along with the measured weight. A verbal description of the vehicle was recorded as an aid in identifying the vehicle with the information already on the recorder in the van.

Figure 2 is a block diagram indicating in a general way the method of reducing the data. The noise from channel "A" was passed through an A-weighting filter and a B-weighting filter (see Appendix H). Each of these outputs fed a wide dynamic range detector and peak-holding circuit, and each output was finally displayed on two meters 10 dB apart in range so as to give a wide dynamic range on one visual reading without frequent scale-changing. This permitted the personnel to view these meters quickly and to then record manually the dBA and dBB levels. In addition, the noise from channel "A" was fed into an amplifier and loudspeaker so the people reducing the data could monitor the noise from each truck for possible abnormalities such as gear-shifting or sudden changes in power level. At the same time, audio channel "B" was amplified and put on a loudspeaker for identification of the vehicle with the data that was recorded at the weighing station. Simultaneously, the video channel was viewed and the time-of-day and speed of the particular vehicle on the picture were recorded. The results of these data as recorded from the audio/video tape and the weighing stations were then punched on computer cards. A computer was then used to do the sorting and correlating, and, finally, the results were plotted on a Calcomp digital plotter. Auguscik-25 (Cont.)

Figure 3 is a view of the microphone location at the Everett site during the December measurements. The microphone with its preamplifier is in the center of the picture. We are looking at the northbound lane, and we see one truck coming into view on the curb lane. This field-of-view is more or less south down the road. The southbound lane is not visible in this picture because it is separated from the northbound lane by a wide, tree-covered median. This was a very desirable site for the measurements as there was no acoustic interference from the southbound lane of traffic.

Figure 4 shows the radar speedometer equipment in position at the side of the highway. This, again, was at the Everett site in December. A large truck can be seen in the curb lane.

Figure 5 is a view of the highway from the instrument van at the Everett site. A truck is in the curb lane approaching the microphone location, the video camera is on the left, and the radar speedometer readout shows the truck's speed as 59 mph. Also shown are the date (December 30, 1971) and time (10:37) the truck passed by.

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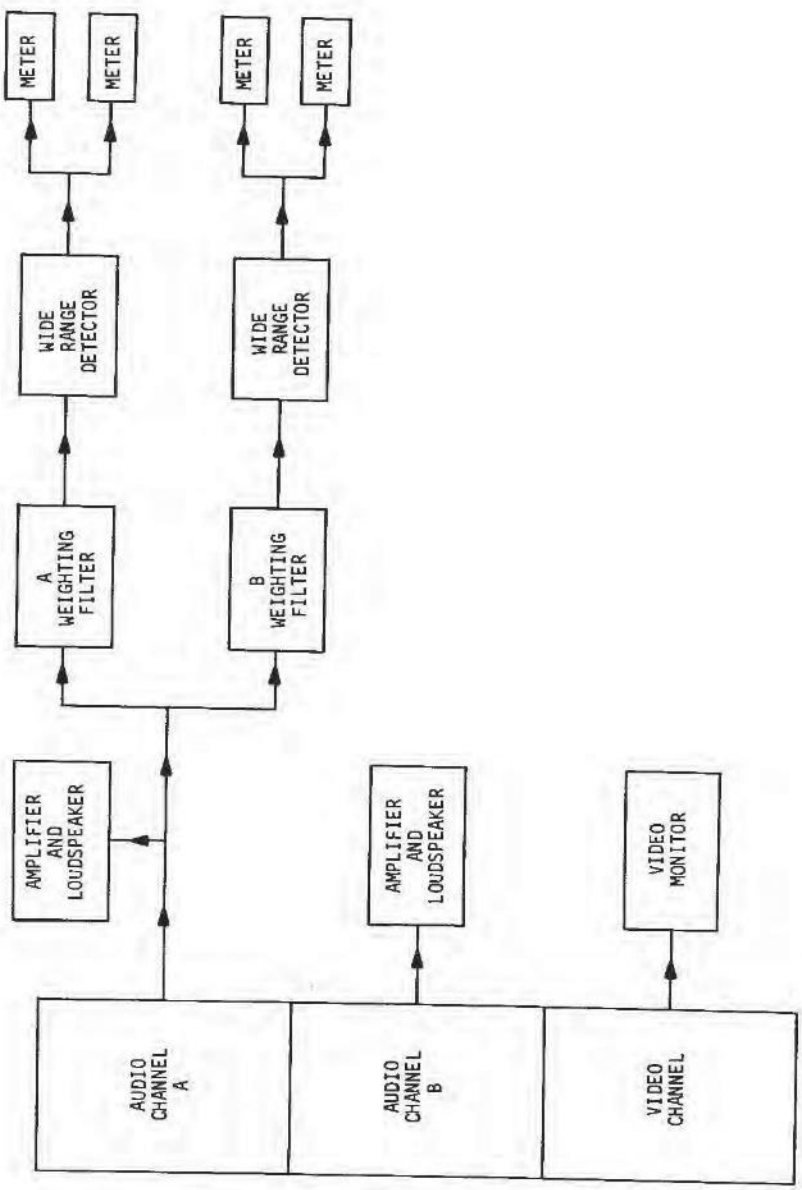

FIGURE 2. BLOCK DIAGRAM OF FIRST STEP IN DATA REDUCTION.

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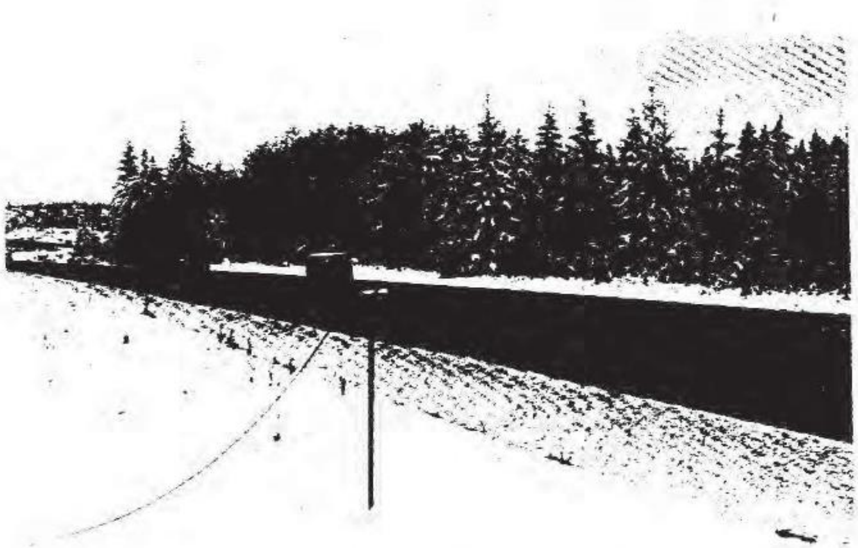

FIGURE 3. VIEW OF THE MICROPHONE LOCATION AT THE EVERETT SITE.

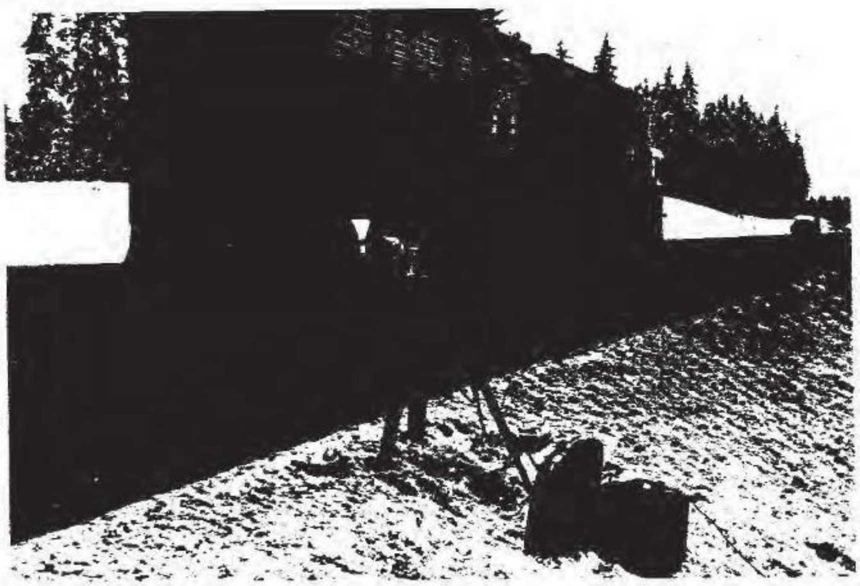

FIGURE 4. VIEW OF THE RADAR LOCATION AT THE EVERETT SITE.

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FIGURE 5. VIEW FROM INSIDE THE VAN AT THE EVERETT SITE.

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Figure 6 is a view looking back from the highway toward the instrument van. Figure 7 was taken inside the weighing station and shows the recording of the weights as the truck passed over the scales, one axle or group of axles at a time. The weights were summed to get the total weight of each truck. The State's weight controllers in each of the stations were most helpful in calling out the weights and identifying the classes of trucks to our personnel.

Figure 8 shows Laboratory personnel obtaining mileage and other relevant information from a truck driver and measuring the tire tread depth, etc. Early in the program an attempt was made to correlate tire data with noise level. For this effort we recorded the tire type (with reference to a tire-type chart) and measured the tread depth as well. Figure 9 shows tire tread depth being measured. As can be seen in this picture, the two tires on the same axle are different, and it turns out that most trucks have a very "mixed bag" of tires. The steering tires are generally of the ribbed type, such as is shown with the depth indicator. The traction tires are generally of the lug type, such as the tire immediately next to the ribbed tire on the same axle. The remaining tires on the trailer can be almost anything. Apparently, as the tractor tires become worn they are moved to the trailer randomly; often the generalization about the steering and traction tires does not hold. All sorts of combinations of tire types were found--to such an extent that any correlation of noise with tire type is impractical from our data. Studies correlating tire noise with tire types will have to be made by controlling the tires on the truck at the time of noise measurements.

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Figure 10 is a view of the highway location for the Fife measurements. The van is in the left center, and the northbound highway is beyond the microphone which is just showing in the center of the picture.

As shown in Fig. 12, five different sites were used in the noise study. Three of the sites (Everett, Fife, and Cle Elum) were on highways which had State Patrol weighing stations; one site (Nisqually) was on a section of U.S. Interstate 5 where there was no weighing station; and the fifth location was on a well-traveled street in a 35 mph zone in an industrial area of Seattle where again there was no weighing station. Except for the measurements at this latter site, the microphone was placed 50 ft from the center line of the curb lane and data were taken only on vehicles in this lane. Having the data on video tape makes it quite easy to verify that the vehicle being measured was in the appropriate lane and that the noise data were not being distorted by vehicles in other lanes. In each case traffic was traveling up the indicated grades.

FIGURE 6. VIEW OF THE VAN SET UP AT THE EVERETT SITE.

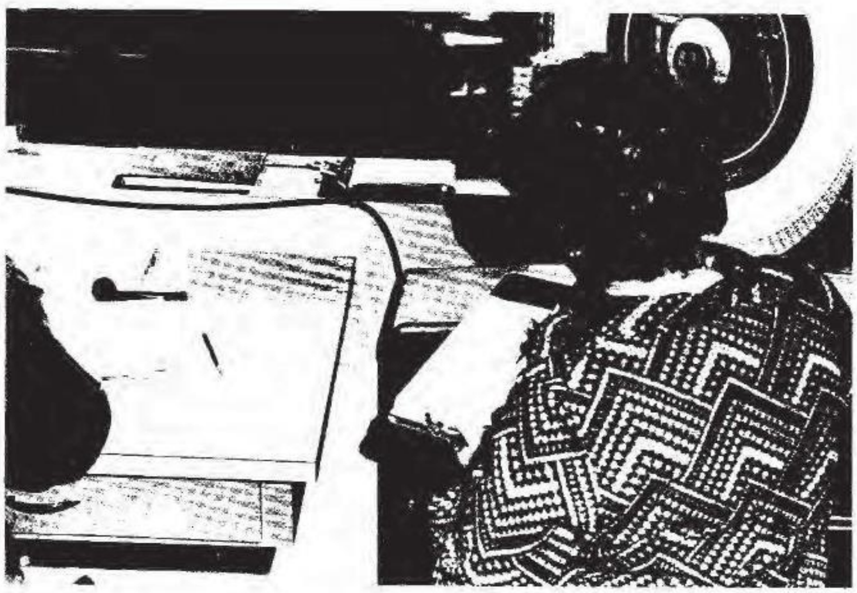

FIGURE 7. VIEW OF THE RECORDING OF TRUCK WEIGHTS AT THE EVERETT WEIGH STATION.

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FIGURE 8. VIEW OF TRUCK DRIVER BEING INTERVIEWED AT THE EVERETT WEIGH STATION.

FIGURE 9. VIEW OF TIRE TREAD DEPTH MEASUREMENT AT THE EVERETT WEIGH STATION.

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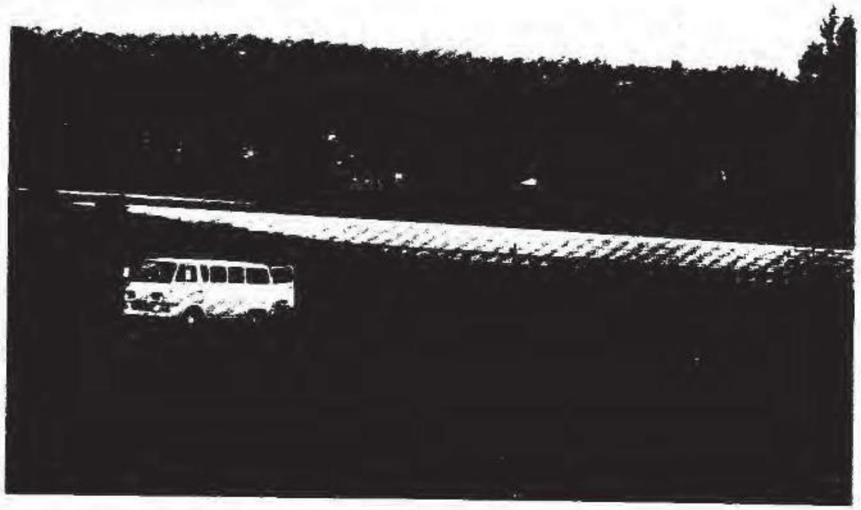

FIGURE 10. VIEW OF THE VAN LOCATION AT THE FIFE SITE.

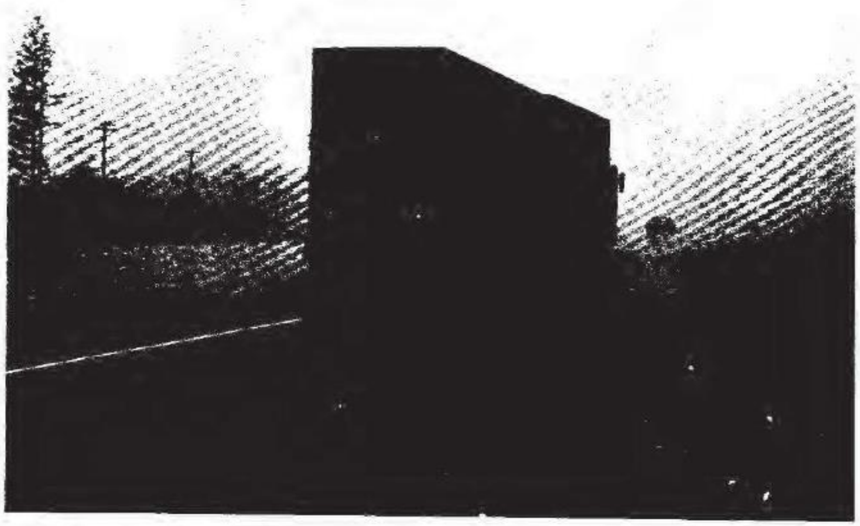

FIGURE 11. VIEW OF A TRUCK ON I-5 DURING A HEAVY RAIN AT THE FIFE SITE.

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Location	Highway Grade	Microphone Location
Everett	0.3%	The microphone was placed 50 ft from the center of the outside northbound lane of U.S. Interstate 5 directly west of Peters Place near the southern city limits of Everett. The area is approximately 3/4 mile south of Scale 38 which is just south of Everett, Washington.
Cle Elum	flat	The microphone was placed 50 ft from the center of the outside westbound lane of U.S. Interstate 90, 200 ft west of the overpass going to Roslyn on State Highway 903. The area is approximately 1/2 mile east of Scale 53, 3-1/2 miles east of Cle Elum, Washington.
Fife	2.8%	The microphone was placed 50 ft from the center of the outside northbound lane of U.S. Interstate 5, approximately 200 ft north of the 70th Ave. E. overpass to Fife, Washington. The area is approximately 1/2 mile south of Scale 26.
Nisqually	3.13%	The microphone was placed 50 ft from the center of the outside southbound lane of U.S. Interstate 5, approximately 200 ft south of the North Meridian Road overpass near Nisqually, Washington.
Sixth & Hanford, Seattle	flat	The microphone was placed 50 ft from the center of either the inside or outside southbound lane of 6th Ave. S. across from the entrance of Hanford St.

FIGURE 12.

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For large, noisy trucks, the data were considered valid even if a car or two were nearby, provided the truck was in the curb lane. For automobiles or trucks with low noise levels, we did not consider the data valid unless the vehicle in question was in the curb lane and there were no other vehicles in other lanes at that particular time.

The traffic was so heavy at the Fife location that it was practically impossible to get any automobile data meeting the above criteria. Whenever there was a car in the curb lane there was nearly always a second car in another lane to invalidate the reading. It was possible to get more automobile data at the Everett site since the traffic was not as heavy and was better spaced, and occasionally there was a single car proceeding in the curb lane. It should be pointed out that the faster cars seldom use the curb lane, so our automobile measurements at this site were primarily of slower cars. Since the trucks were turning into the weighing station three-fourths of a mile up the road, they were, for the most part, in the curb lane and thus could be measured validly.

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The best high-speed automobile data were taken at the Cle Elum site since the traffic load was very light and most of the cars, fast and slow, were in the curb lane. The Nisqually site, on the long up-grade hill on U.S. Interstate 5 northeast of Olympia, did not have a weighing station. This location was chosen in order to get measurements of noise levels produced on a relatively steep grade. This grade measures 3.13%, not much steeper than the Fife site where the grade was 2.8%; however, the Nisqually grade is longer, and measurements were made at a position about two-thirds to the top. At this site the data show a great number of trucks with considerably slower speeds, the speeds probably being limited by engine power.

DATA

Figure 13 is a histogram of all the trucks measured; the sample size is 1,433. As can be seen, this histogram peaks at about 85 and 89 dBA. There were 170 trucks out of this sample which read 85 to 86 dBA and five trucks which fell between 95 and 96 dBA.

Figure 14 is the cumulative frequency plot of the same data shown on Fig. 13. Note that 90% of the trucks were noisier than 82.5 dBA, half were noisier than 86 dBA, and 10% were noisier than 91 dBA.

Figure 15 shows both the cumulative frequency plot of Fig. 12 and a plot of data taken by the California Highway Department on that state's roads. (The California study has data only for this type of plot, i.e., there are no data on speeds, weights, classes, etc. on trucks.) This plot shows that the trucks in this Washington State study are a little noisier than the trucks in the California study; however, the difference is so small as to be insignificant and could well be a happenstance of the sample taken. At the 50% cumulative point there is only 0.5 dBA difference--this close agreement strengthens the validity of both studies.

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Figure 16 is a cumulative frequency plot showing each of the test sites plotted separately. As expected, the Nisqually site is the noisiest but not by a great deal; these data do not differ much from the springtime data taken at the Everett site. An examination of the noise versus speed curve for the two sites (see Appendices D and E, pages D7 and E3) shows that the trucks at the Everett site were moving substantially at full speed, whereas there is a very wide variation in speed, with many slow trucks, at the Nisqually site. The speed of many of the trucks on the Nisqually grade was engine-limited and the trucks slowed down sufficiently so that their noise levels were not much greater than those at the Everett site.

The quietest sites were Cle Elum and Fife. There were several reasons why Cle Elum was quieter; the terrain was flat, and during the time of measurement (10:00 a.m. - 3:00 p.m.) there were many apparently empty loads heading west, thus reducing the total weight. At the Fife site the noise level was low despite the grade. There was rain and fog during most of the one-day's work at this site, and perhaps this caused the trucks to proceed at a slower pace. In addition, the only suitable acoustic site was somewhat closer to the turn-off for the weighing station than had been the case at the other sites, and thus most of the trucks were slowing down in preparation for the exit. Although we had hoped to determine whether the noise levels would be significantly affected by the rain, this was not possible because of the reduced speeds and the effects of other parameters. However, it appears that rain does not have a significant effect on radiated noise. (Rain may have a greater relative effect on slow traffic (below 35 mph) noise, but we do not have data to substantiate this surmise.)

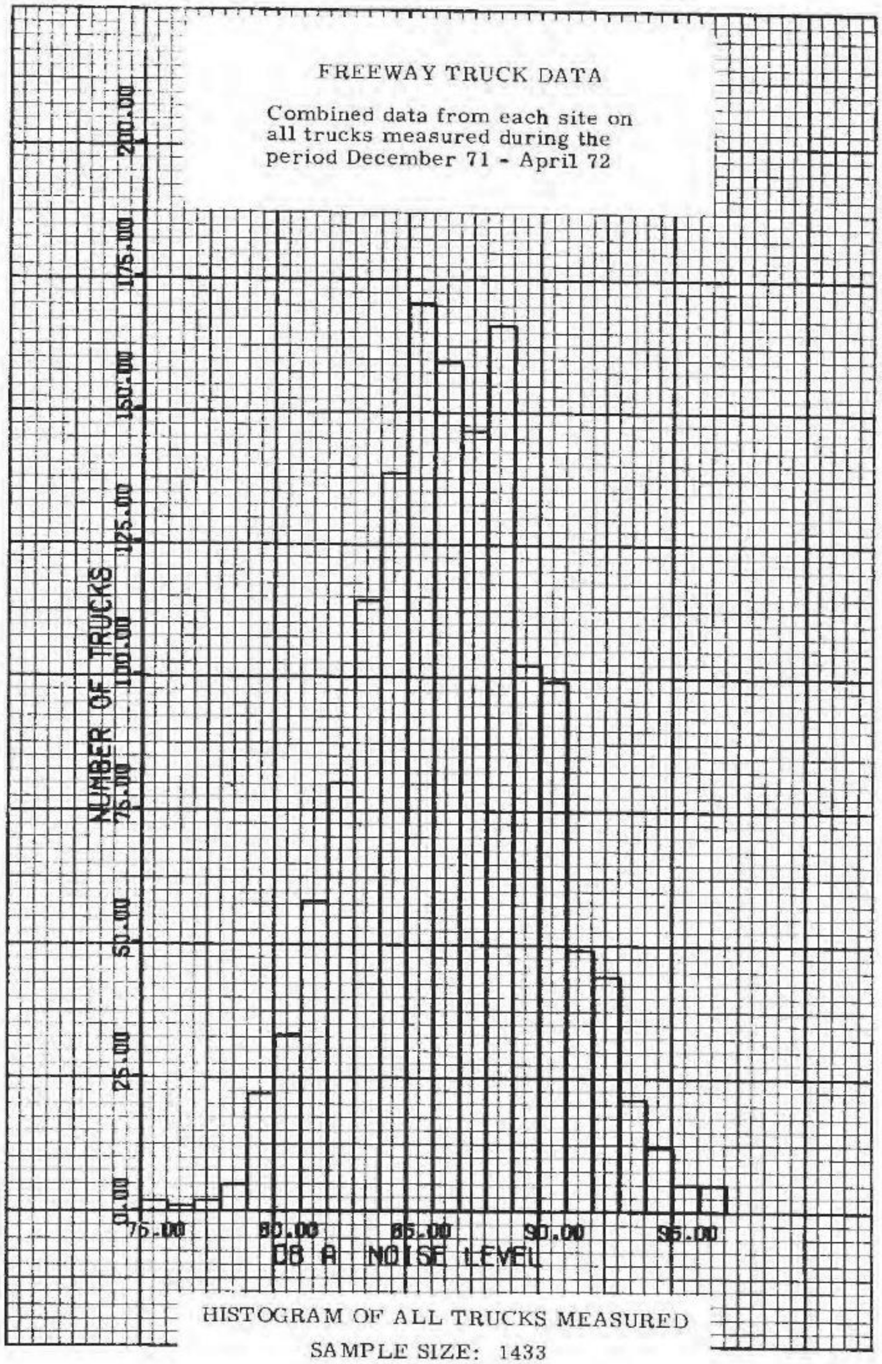

FIGURE 13.

Auguscik-25 (Cont.)

16

Auguscik-25
(Cont.)

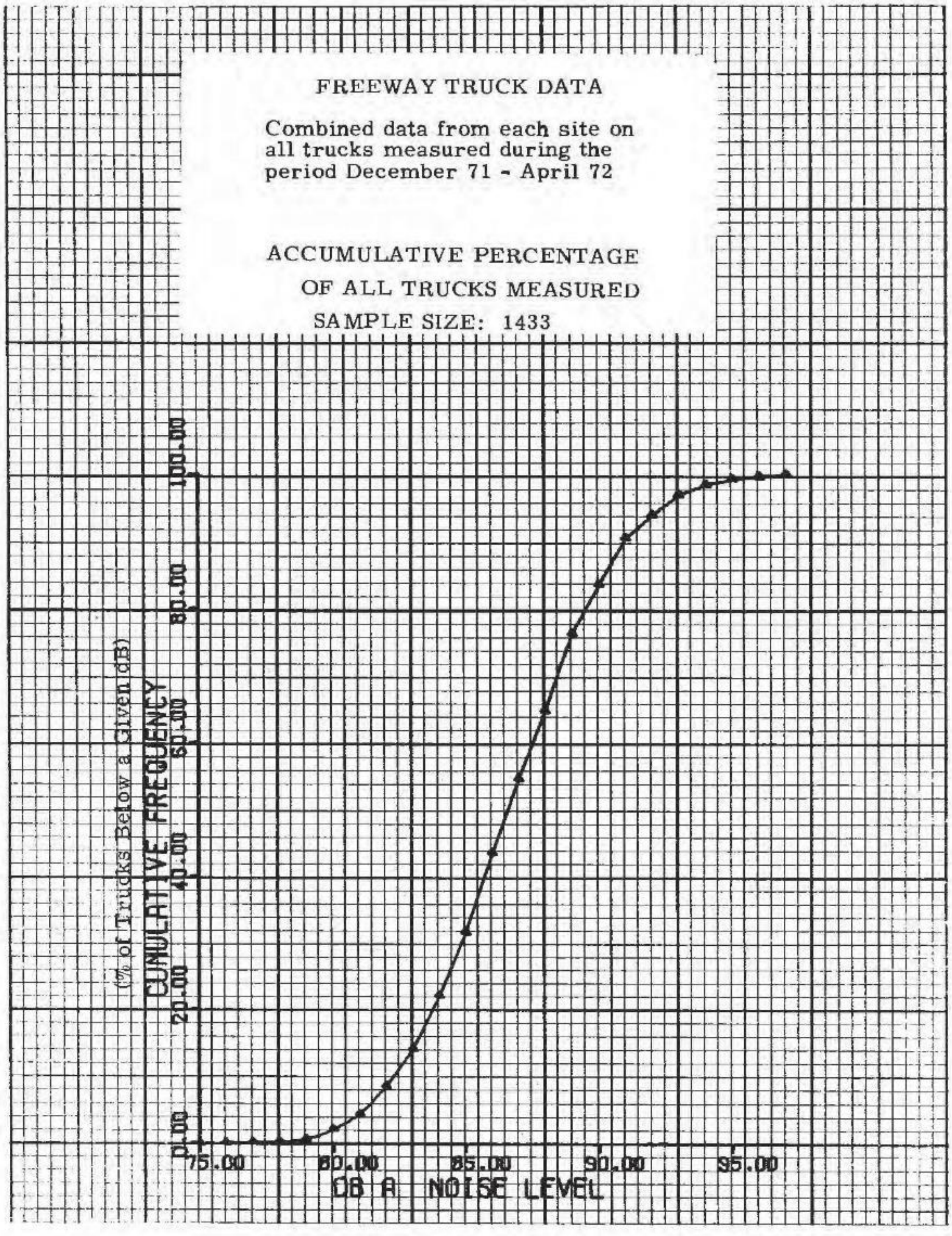

FIGURE 14.

17

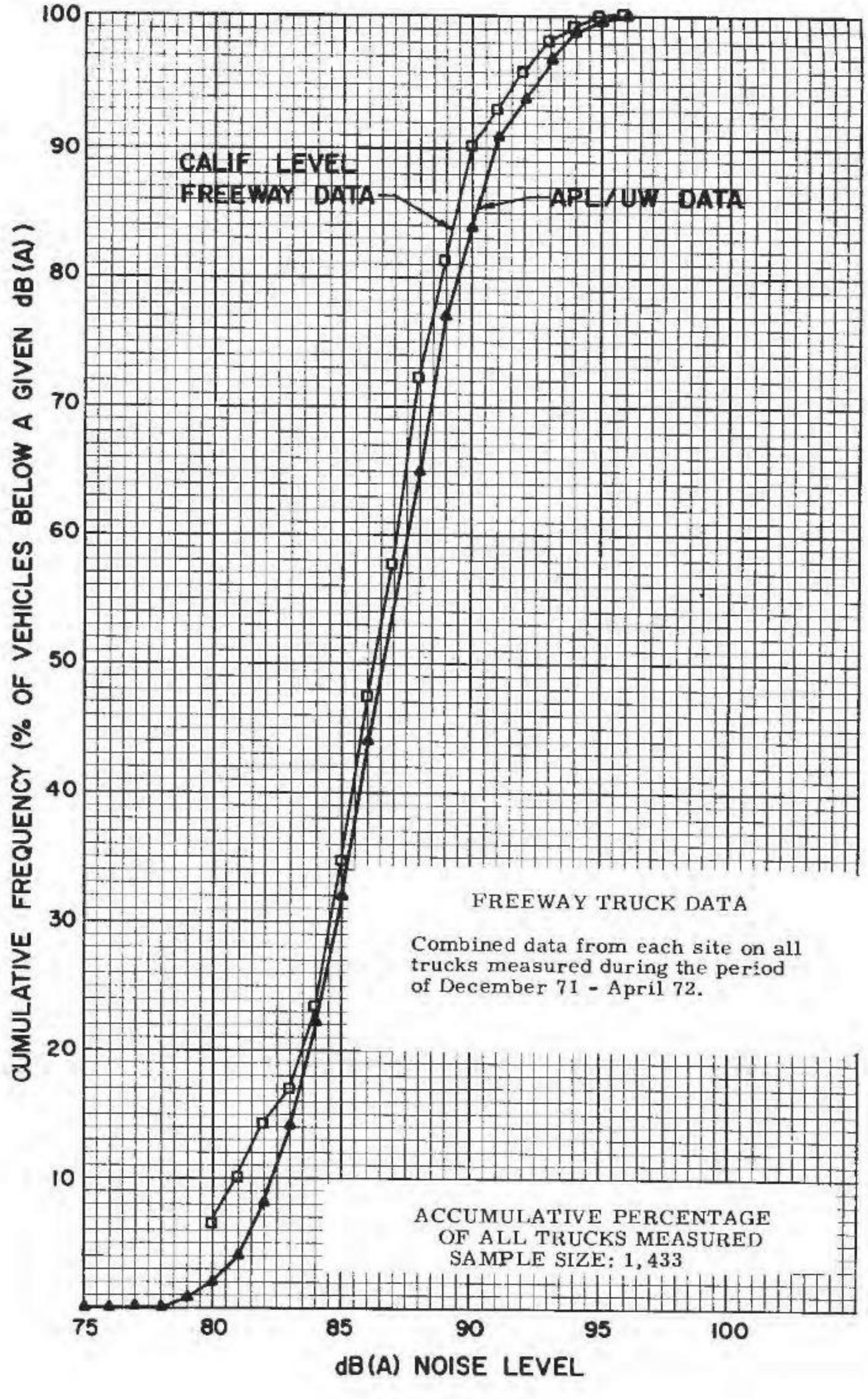

FIGURE 15.

Auguscik-25
(Cont.)

18

Auguscik-25
(Cont.)

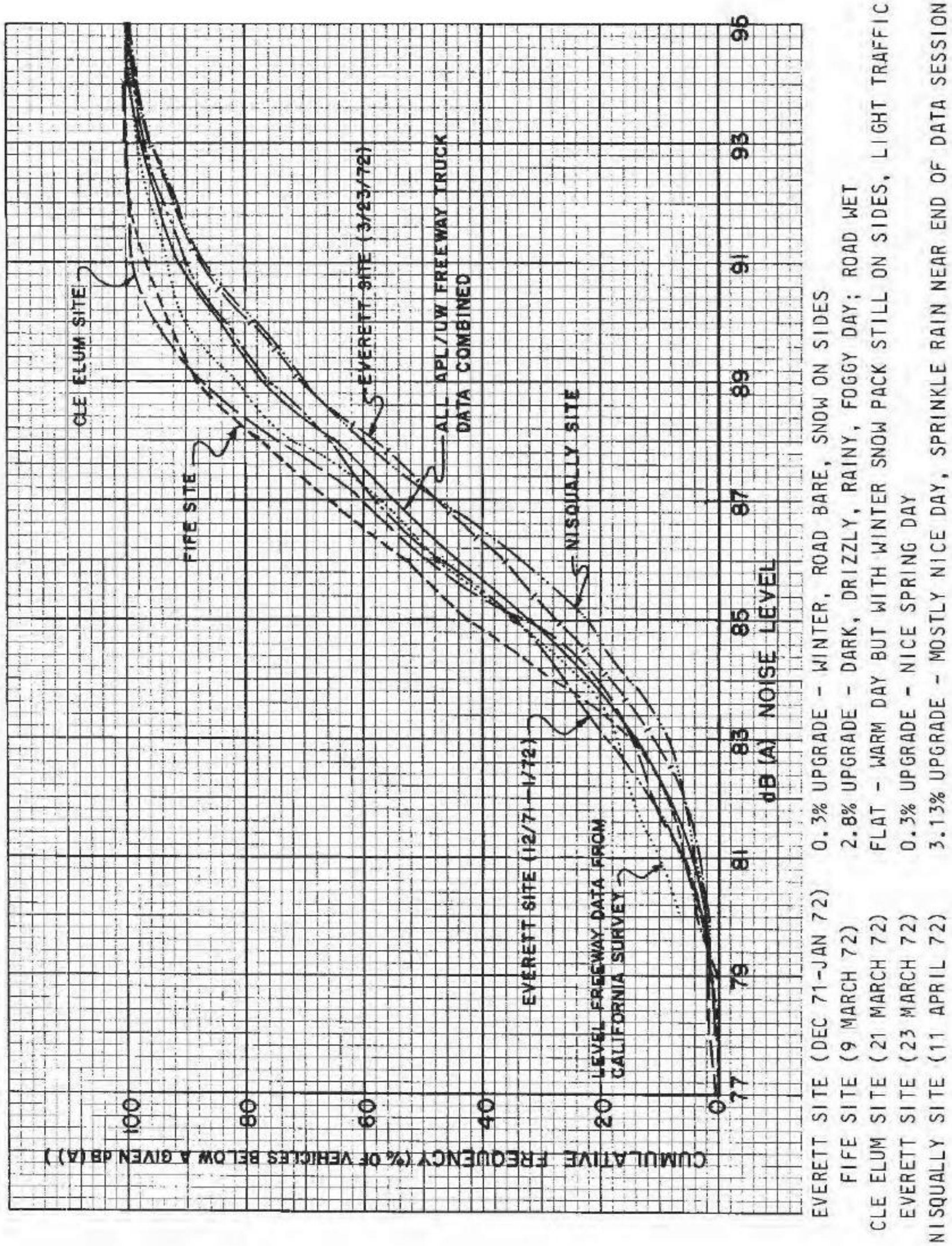

FIGURE 16.

19

The plot of the data taken at the Everett site in mid-winter shows only a slightly less noisy cumulative percentage curve than the springtime data; the difference at the 50% cumulative point is only 0.3 dBA, which is insignificant. However, it is possible that the colder tires were somewhat less noisy and/or the particular sample of trucks had slightly different statistics. Note that the total spread of the data at the 50% point for all the sites is only about 1.5 dBA, which is very small. The average person could barely detect a 1.5 dBA change even if he heard one level right after the other. The California data are plotted also and appear more or less in the middle of the data from all of the sites.

Figure 17 shows the various classes of trucks as categorized by the vehicle loading chart of the Washington State Highway Department, dated July 1963. Also shown on this chart are eleven different symbols, one for each truck class. These symbols are used extensively in many of the graphs presented here; e.g., the letter Z represents a Class 8 truck, the configuration of which is shown in Fig. 17.

Auguscik-25 (Cont.)

Figure 18 is a plot of noise level in dBA versus measured gross weight in thousands of pounds. Each data point symbol corresponds to a class of truck, as explained in the preceding paragraph. Note that there is a general trend for the vehicle to radiate more noise as its gross weight increases. There is, however, a wide spread in noise levels at any given weight. For example, at the 75,000 lb level there is one truck below 85 dBA and another in excess of 96 dBA; also, at the 10,000 lb level there are trucks below 77 dBA and at least one above 91 dBA. This clearly shows that the big, heavy trucks are not the sole offenders, and that there are, indeed, some large heavy trucks which are quiet. The plot of Fig. 18 includes trucks at all speeds and indicates that the quieter ones are the low-speed trucks.

Figure 19 is similar to Fig. 18 except that all the trucks with speeds below 50 mph have been eliminated, leaving trucks which are all going at about the same speed (the speed limit is 60 mph). (It will be seen in later data that there are trucks which exceed this limit.) Once again, it can be seen that there are trucks weighing more than 65,000 lb (as measured at the weighing station) which are below 85 dBA. There are also trucks in this same weight bracket above 96 dBA. Similarly, in the region of 10,000 lb gross weight, there is one truck as low as 77 dBA and another one above 91 dBA. The trend, then, is to greater noise as the vehicle gets heavier, but there is a very wide spread in the truck noise levels. This clearly shows that if all trucks were as quiet as the low 10%, the noise level would be down considerably. Note on this figure that the heavier trucks in this study tend to be predominantly Class 8's. There are also a number of Class 11 trucks among the heaviest weights; at the lighter end of the scale the Class 1's predominate (octagonal symbols).

Auguscik-25
(Cont.)

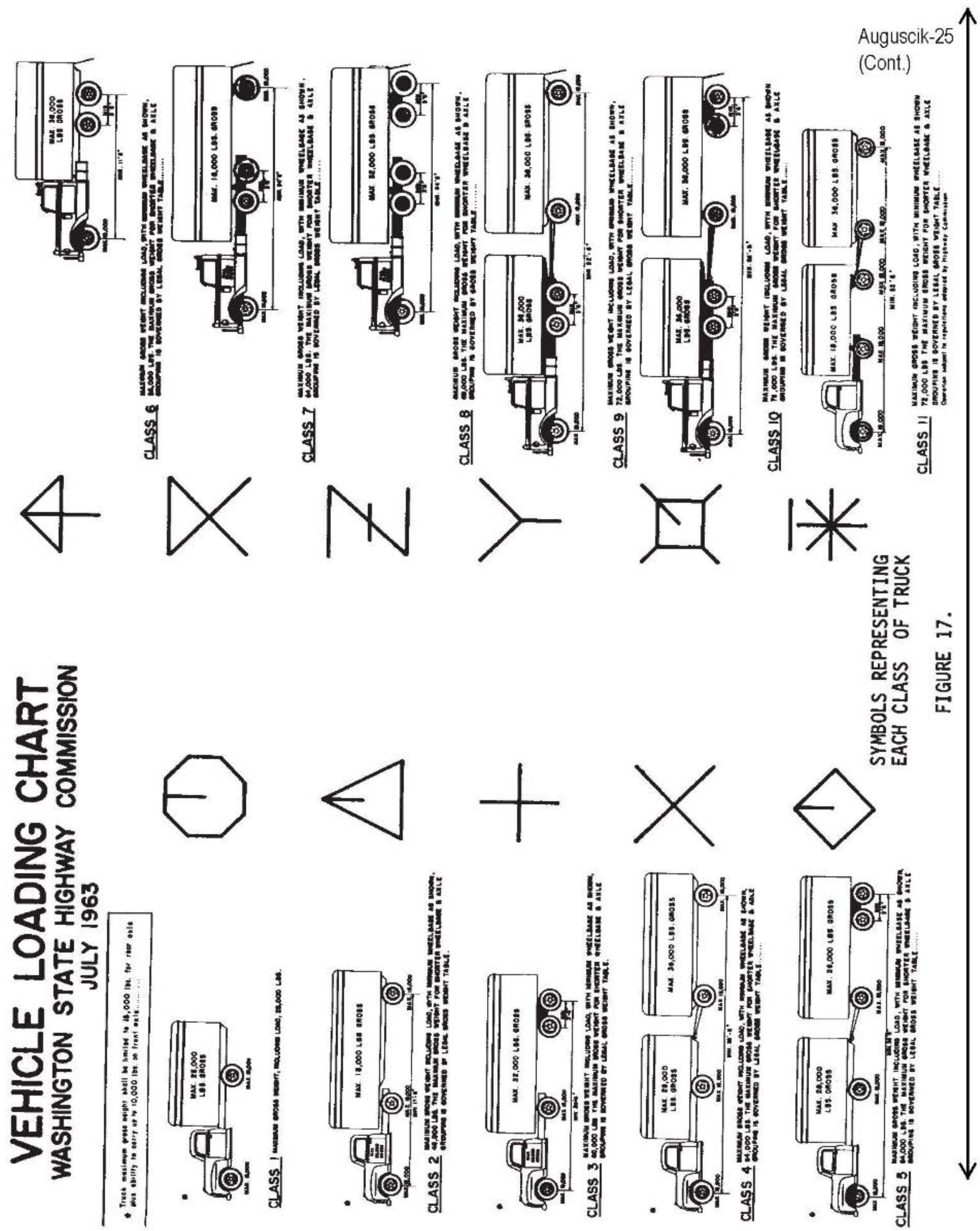

FIGURE 17.

21

Auguscik-25
(Cont.)

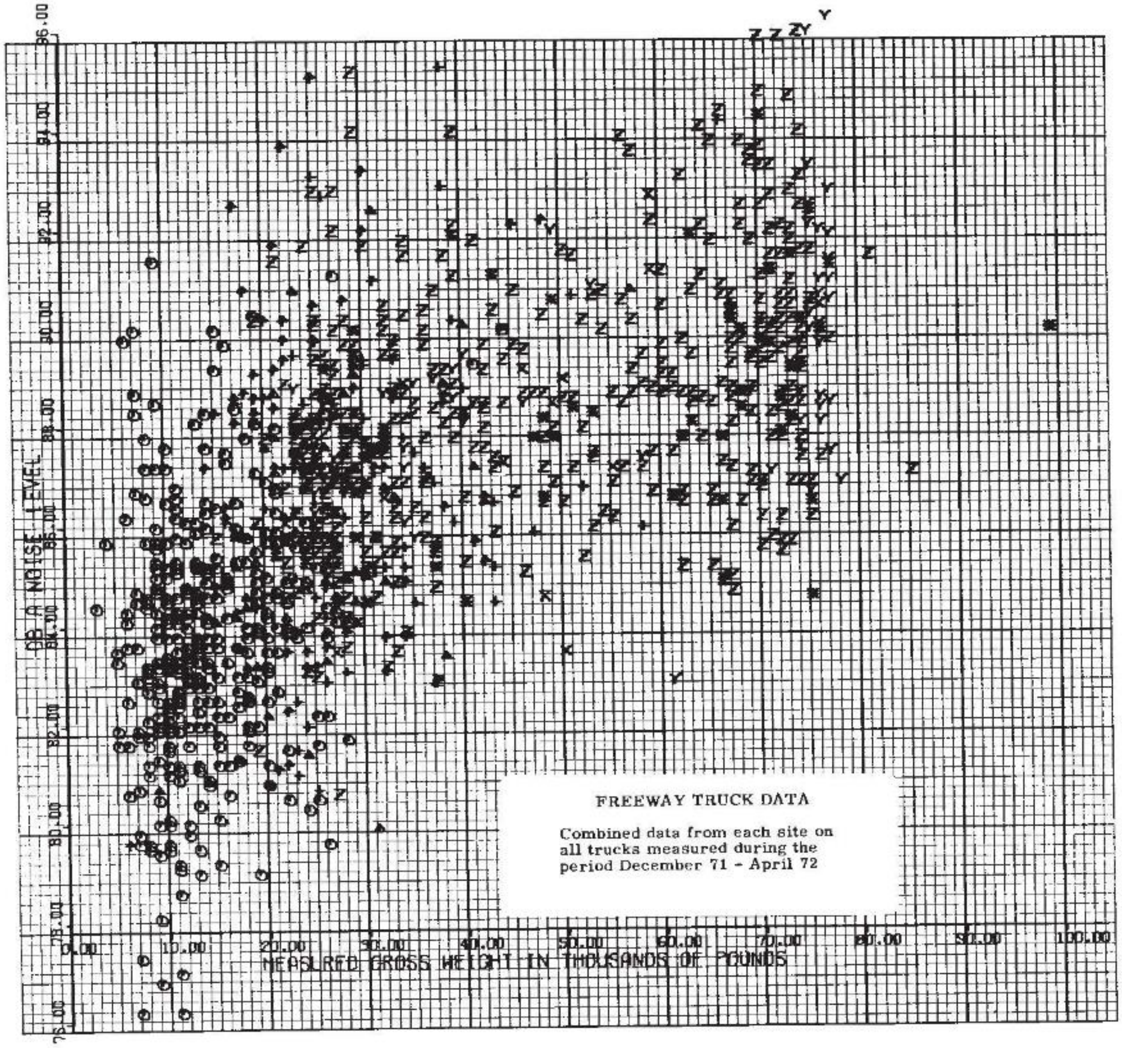

FIGURE 18.

22

Auguscik-25
(Cont.)

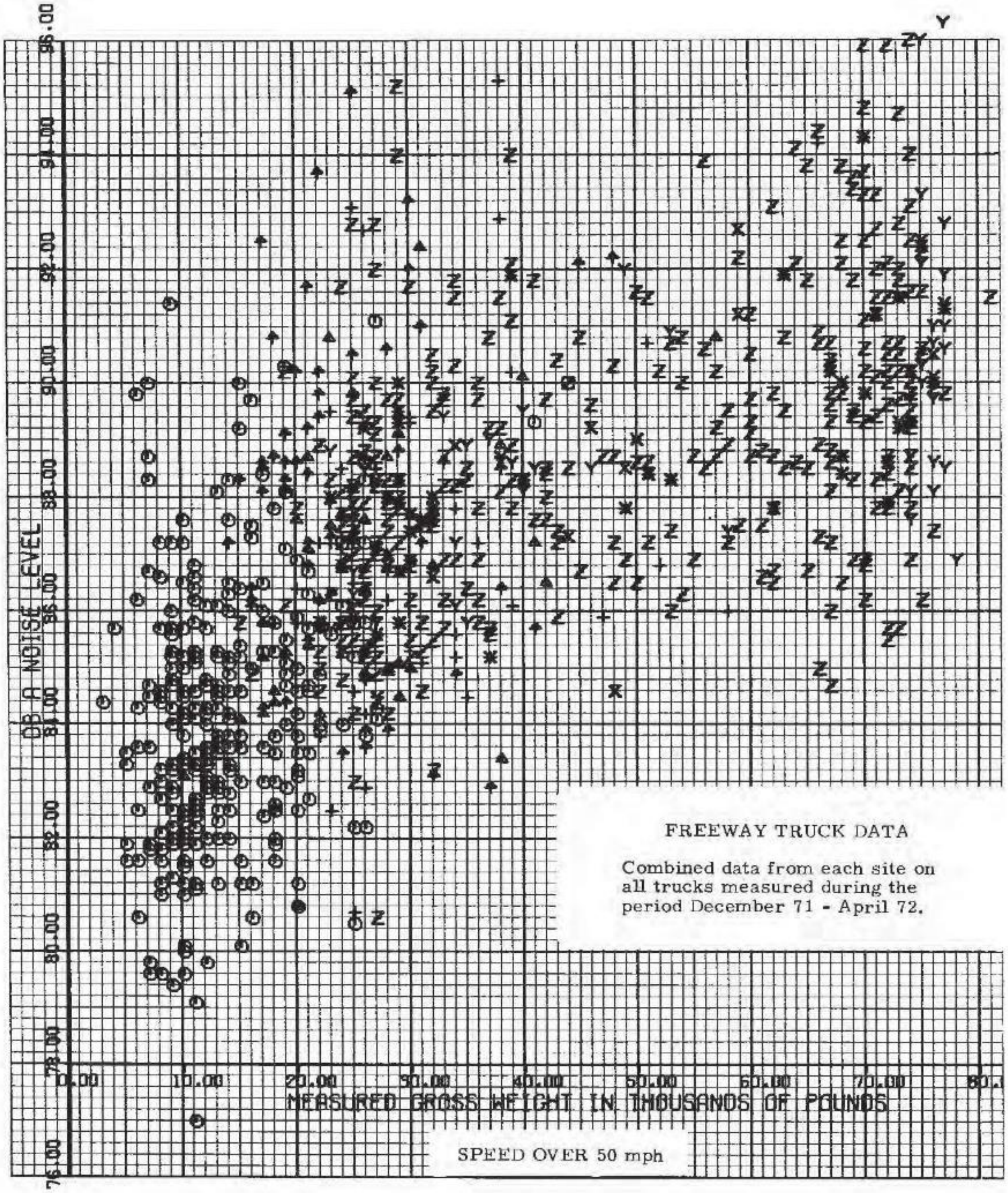

FIGURE 19.

23

Auguscik-25
(Cont.)

Figure 20 is a plot of all the trucks measured, showing their noise levels versus speeds. A Doppler-shift radar unit was used to measure the speed. The noise level shows the trend of increasing noise with speed, but a very wide spread is observed.

In an attempt to eliminate the weight variable from the speed plots, Figs. 21-27 show the trucks in various weight categories, and within each of these categories the dBA versus the speed has been plotted. In Fig. 21 the noise level increases with speed in the under-10,000 lb vehicles, but, again, there is a very wide scatter. As we proceed through these charts, notice the median level of noise increases a little bit with each higher weight category. In practically all of these categories an increase of noise with increase of speed is shown although the scatter in the data is very wide. Several variables, other than weight and speed, contribute to the scatter. These include the adequacy of the muffling system, tires, amount of noise emanating from the supercharger or compressor of the motor, gear noise, etc. None of these are necessarily correlative with either speed or weight.

The question arises as to how much of this noise level could be corrected with adequate mufflers, with no other changes being made to the trucks now on the highways. This question cannot be answered directly and unequivocally from this study. However, the information plotted in Fig. 28 can give a definite clue. At the time the data were reduced, sound levels were recorded not only for the standard A-weighting filter but also for a B-weighting filter. A B-weighting filter is a standard noise measurement frequency response which allows more low-frequency information to be measured; in other words, if a sound has a lot of low-frequency components, it will measure louder on an indicating meter set to the B-scale than it will on one set to the A-scale. It is probably fair to say that the major source of excessive low-frequency sound from trucks is the engine exhaust. Therefore, a poorly muffled vehicle would have a dBB reading which is significantly higher than a dBA reading; there would not be much difference in the dBA and dBB readings from a truck that is adequately muffled. In Fig. 28 the numerical value for the dBA reading for a truck has been subtracted from the numerical value of the dBB reading and the differences have been plotted against the measured gross weight of the truck. Under the foregoing assumptions, those vehicles with large differences can be presumed to be poorly muffled, whereas those with differences between 0 and 1 dB can be presumed to be adequately muffled. It should be pointed out that on this particular chart a truck which is poorly muffled and extremely noisy otherwise would have a relatively low dBB and dBA difference. Another truck might show a large difference, even though its muffler is in good condition, if its tires, engine, gear train, etc. were exceptionally quiet. In general, though, it is probably still valid to consider those vehicles which show more than 2 or 3 dB difference on this plot as being in need of better mufflers.

24

Auguscik-25
(Cont.)

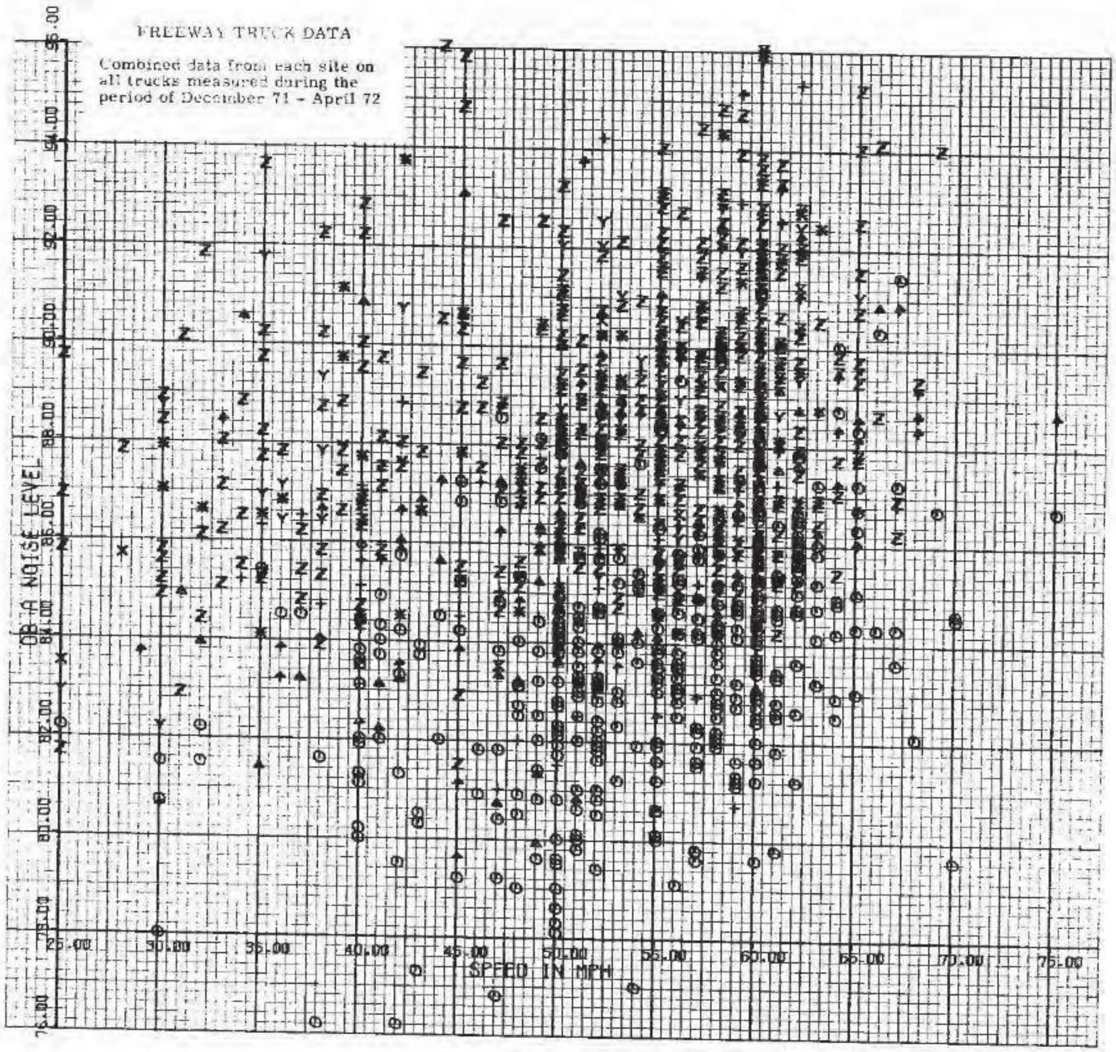

FIGURE 20.

25

Auguscik-25
(Cont.)

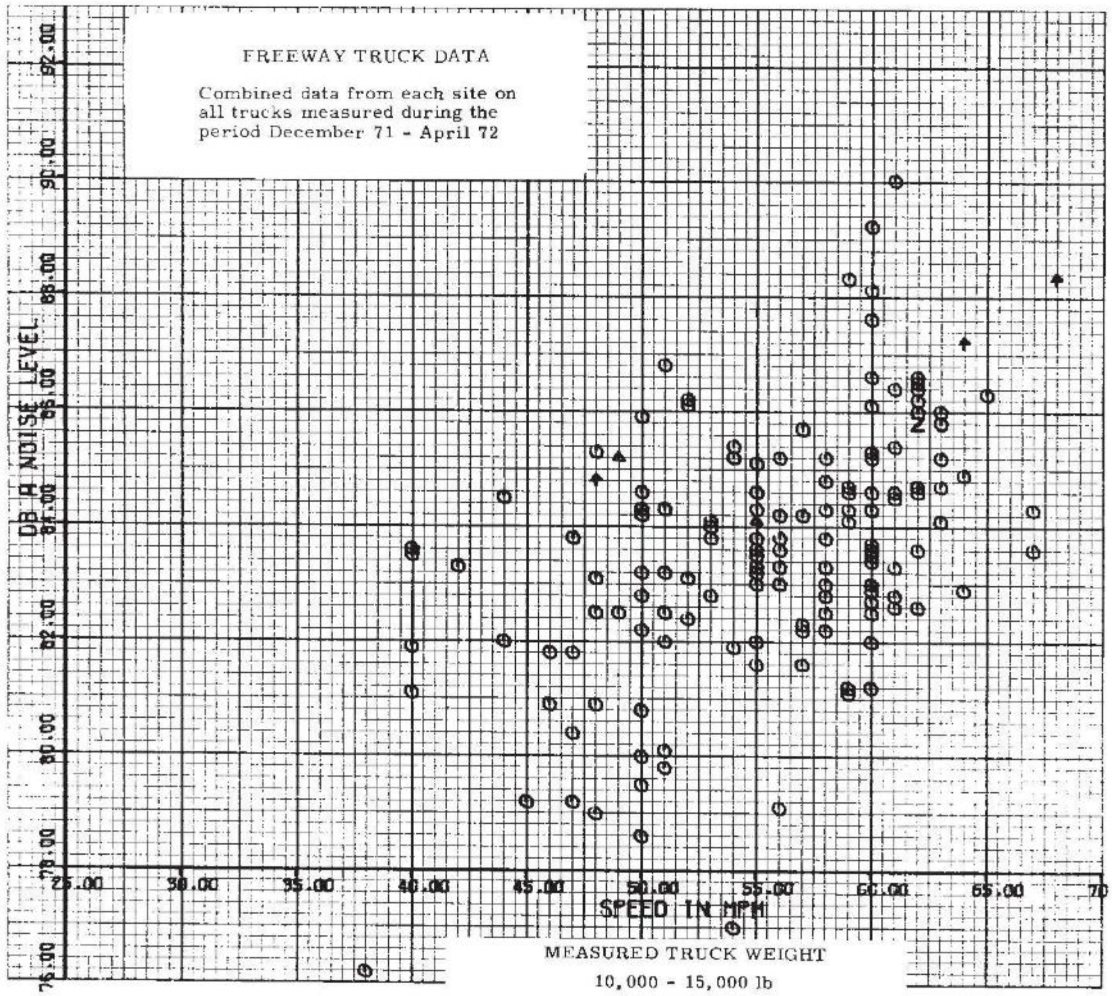

FIGURE 22.

27

Auguscik-25
(Cont.)

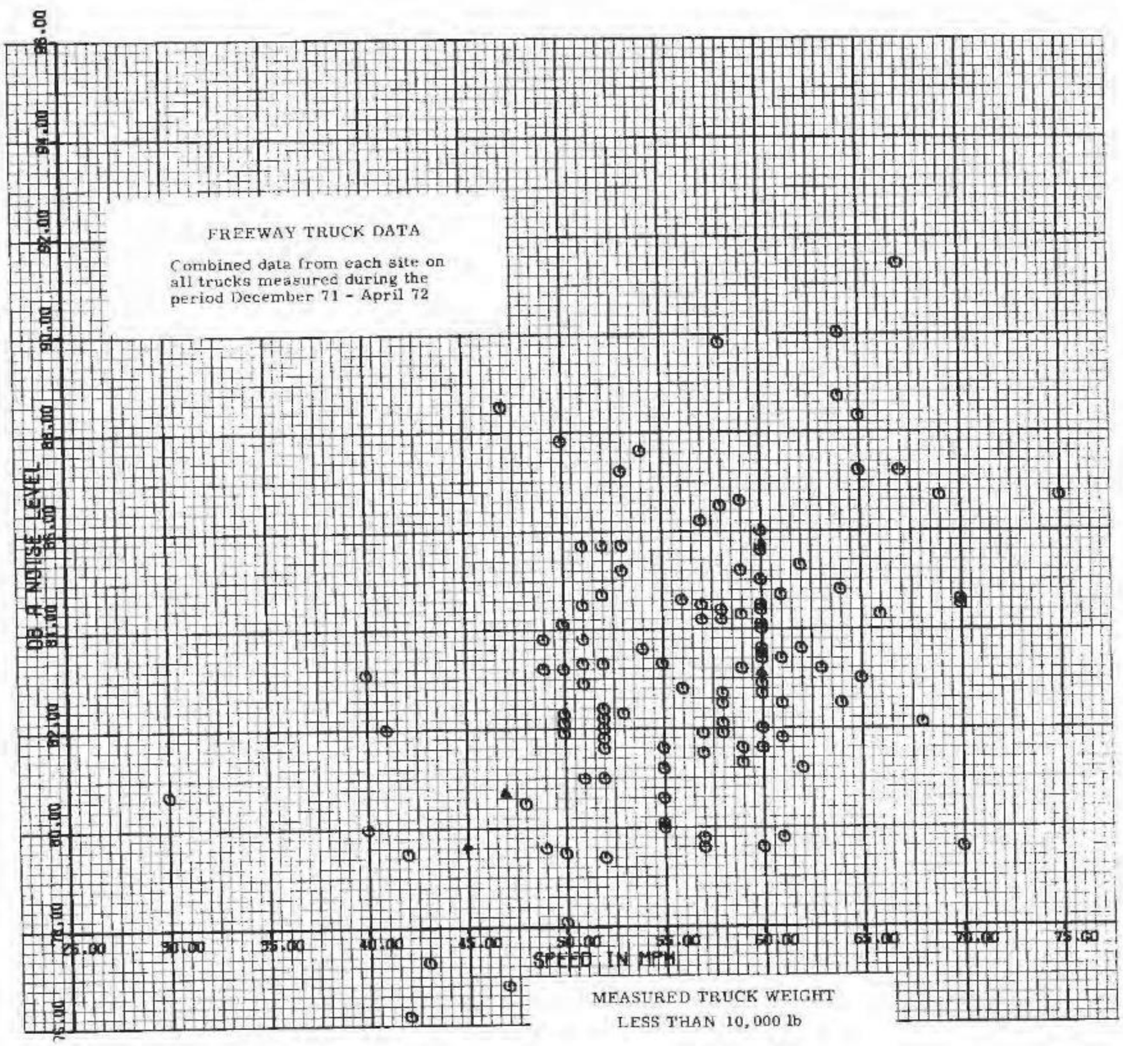

FIGURE 21.

26

Auguscik-25
(Cont.)

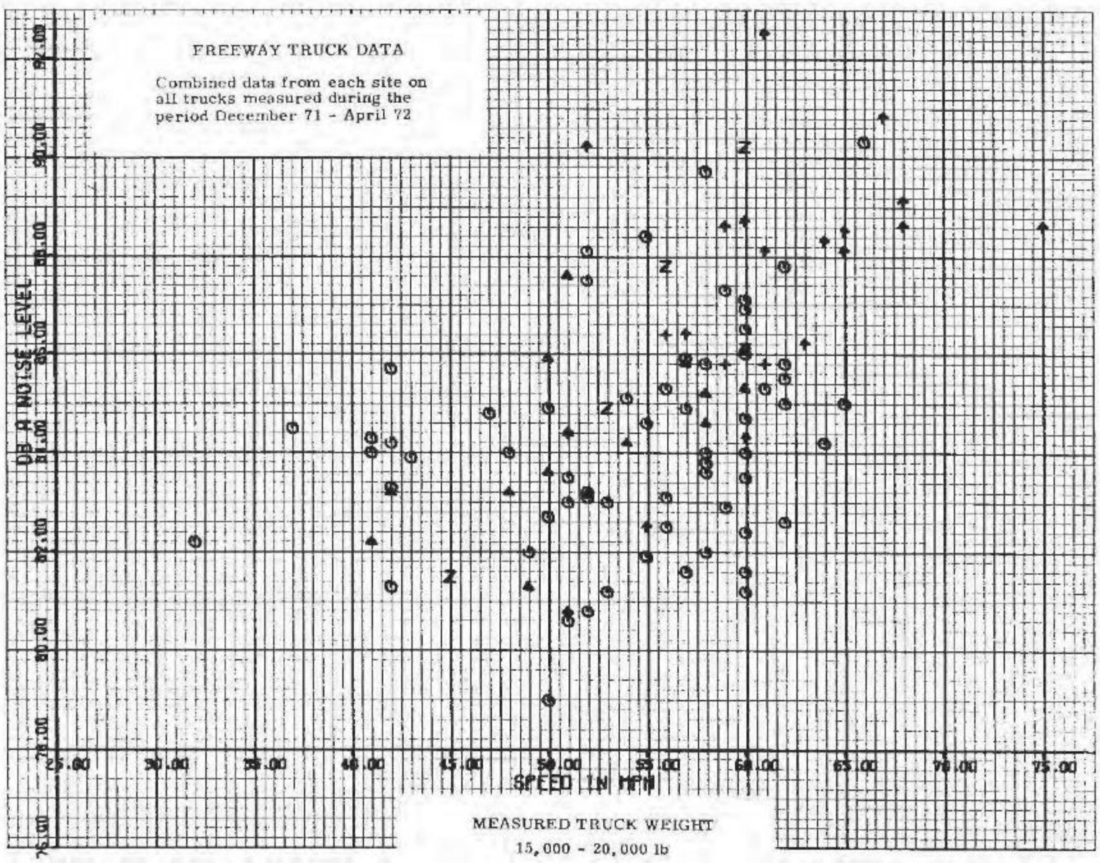

FIGURE 23.

28

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(Cont.)

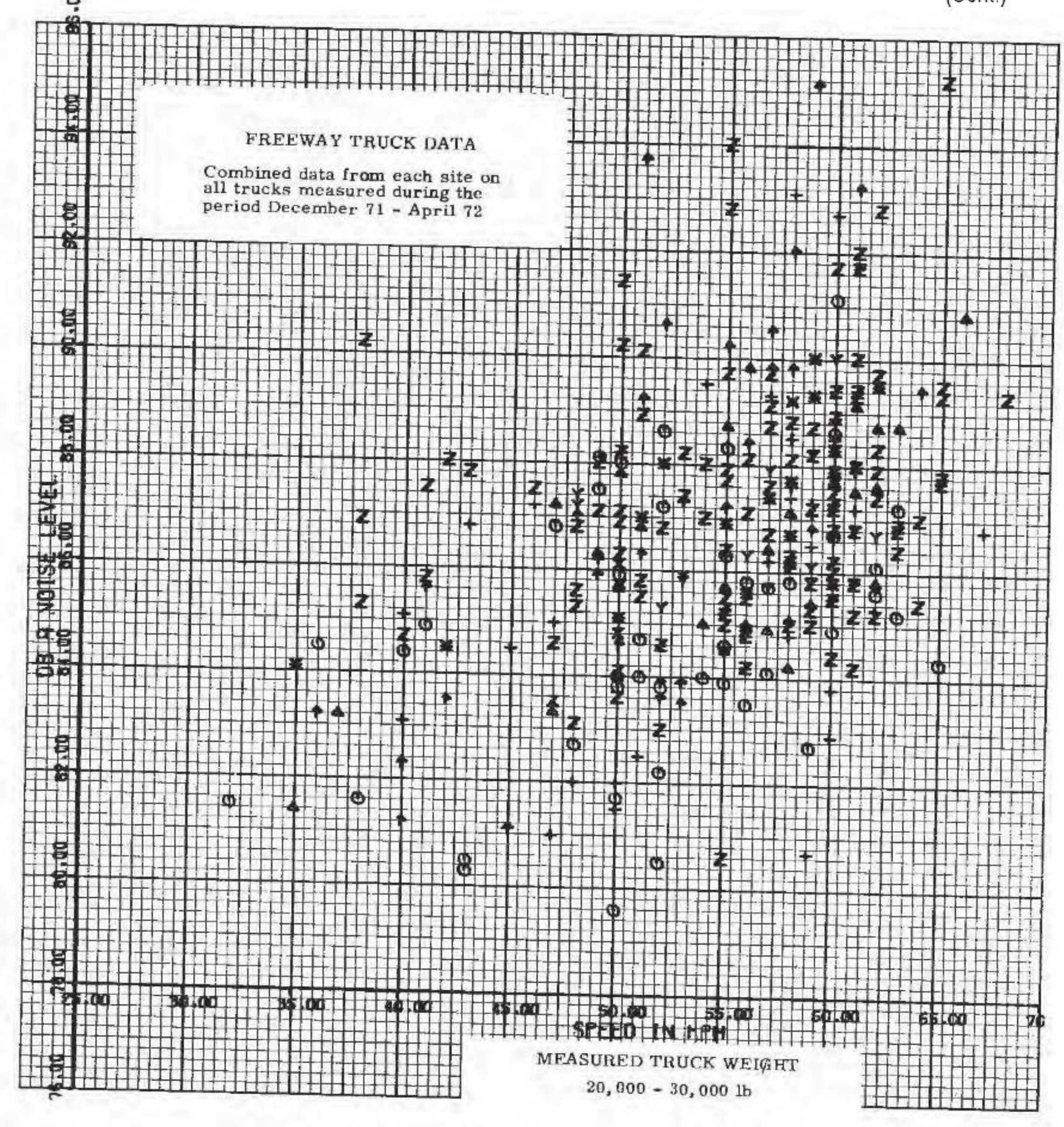

FIGURE 24.

29

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(Cont.)

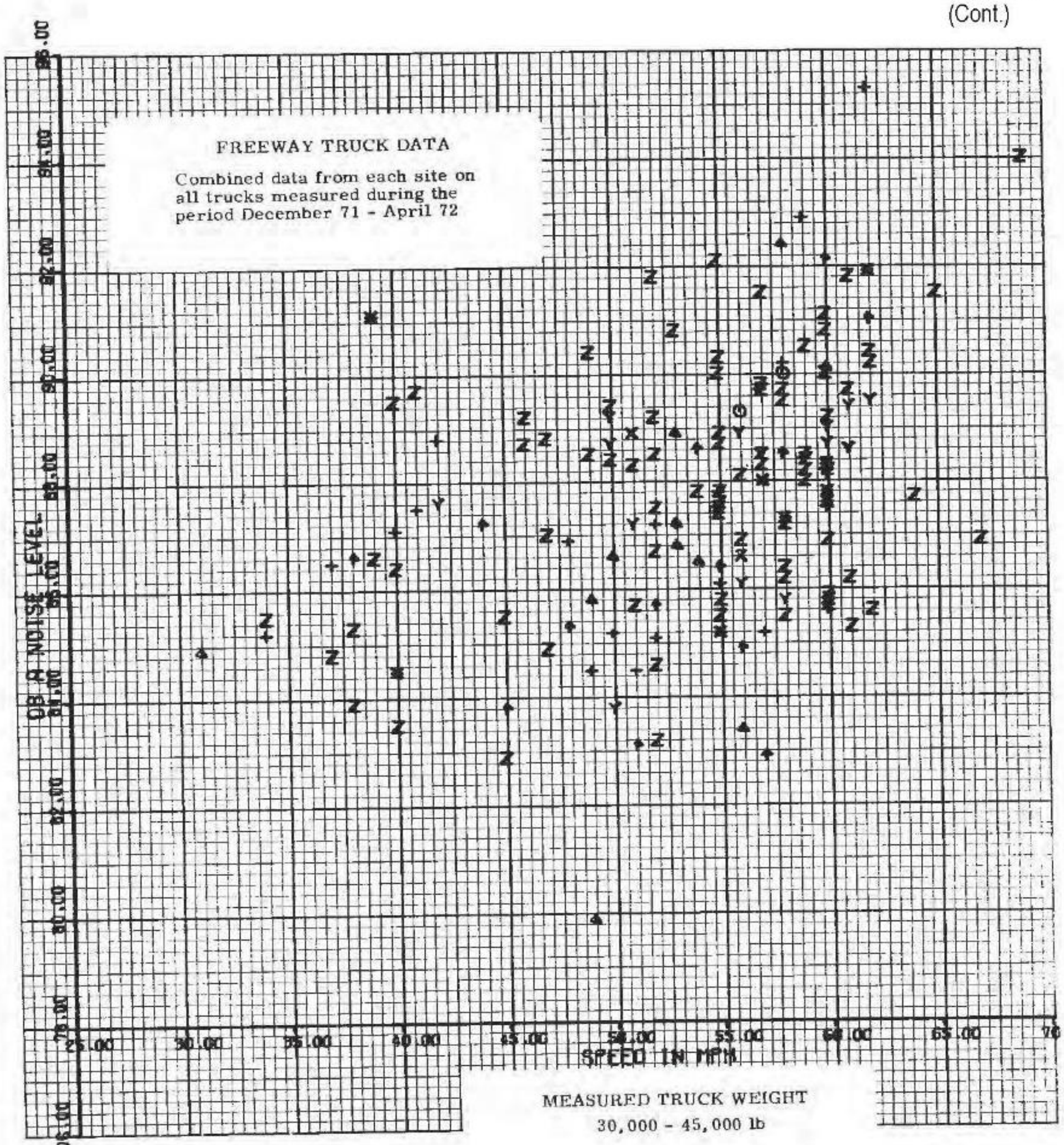

FIGURE 25.

30

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(Cont.)

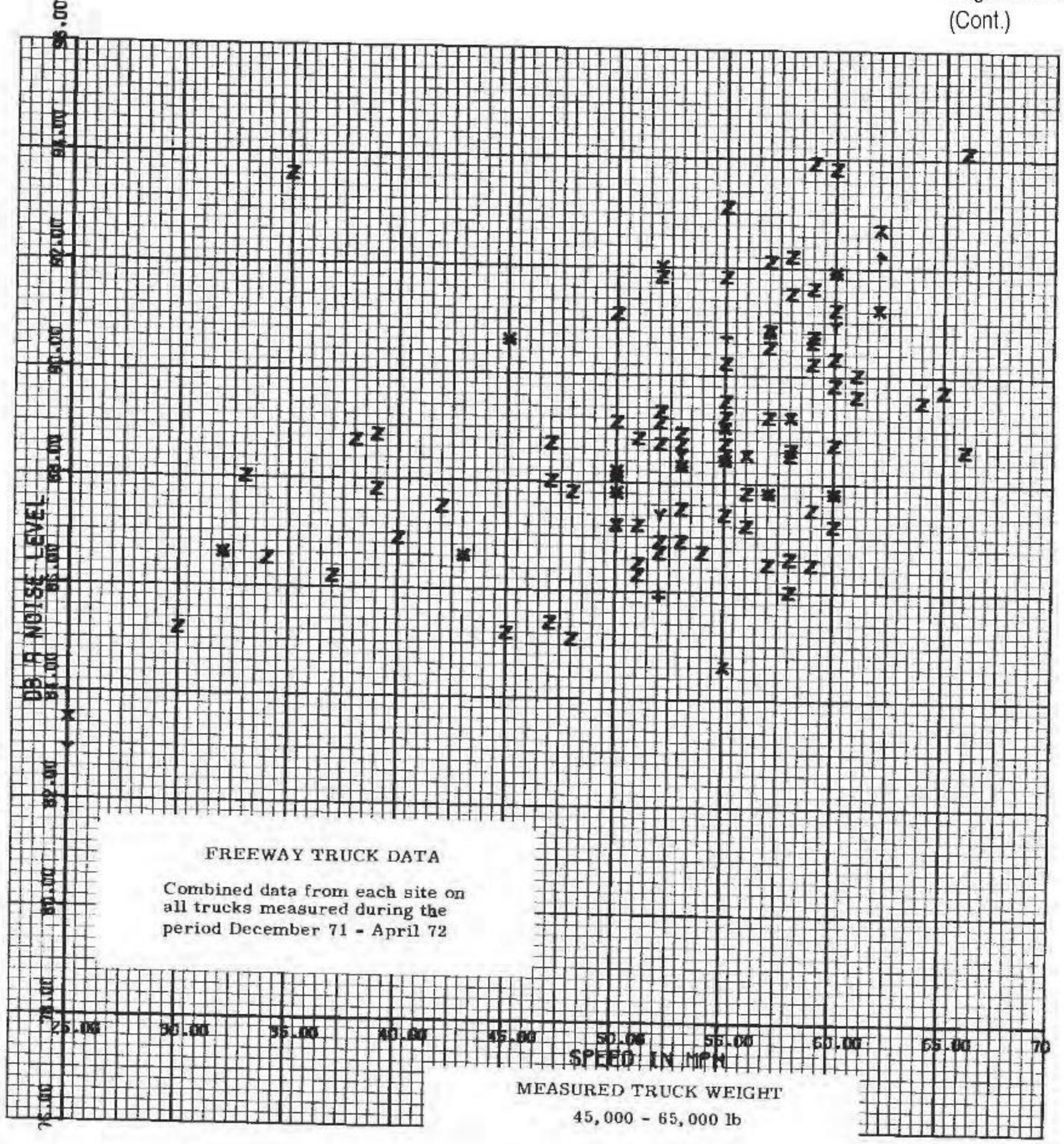

FIGURE 26.

31

Auguscik-25
(Cont.)

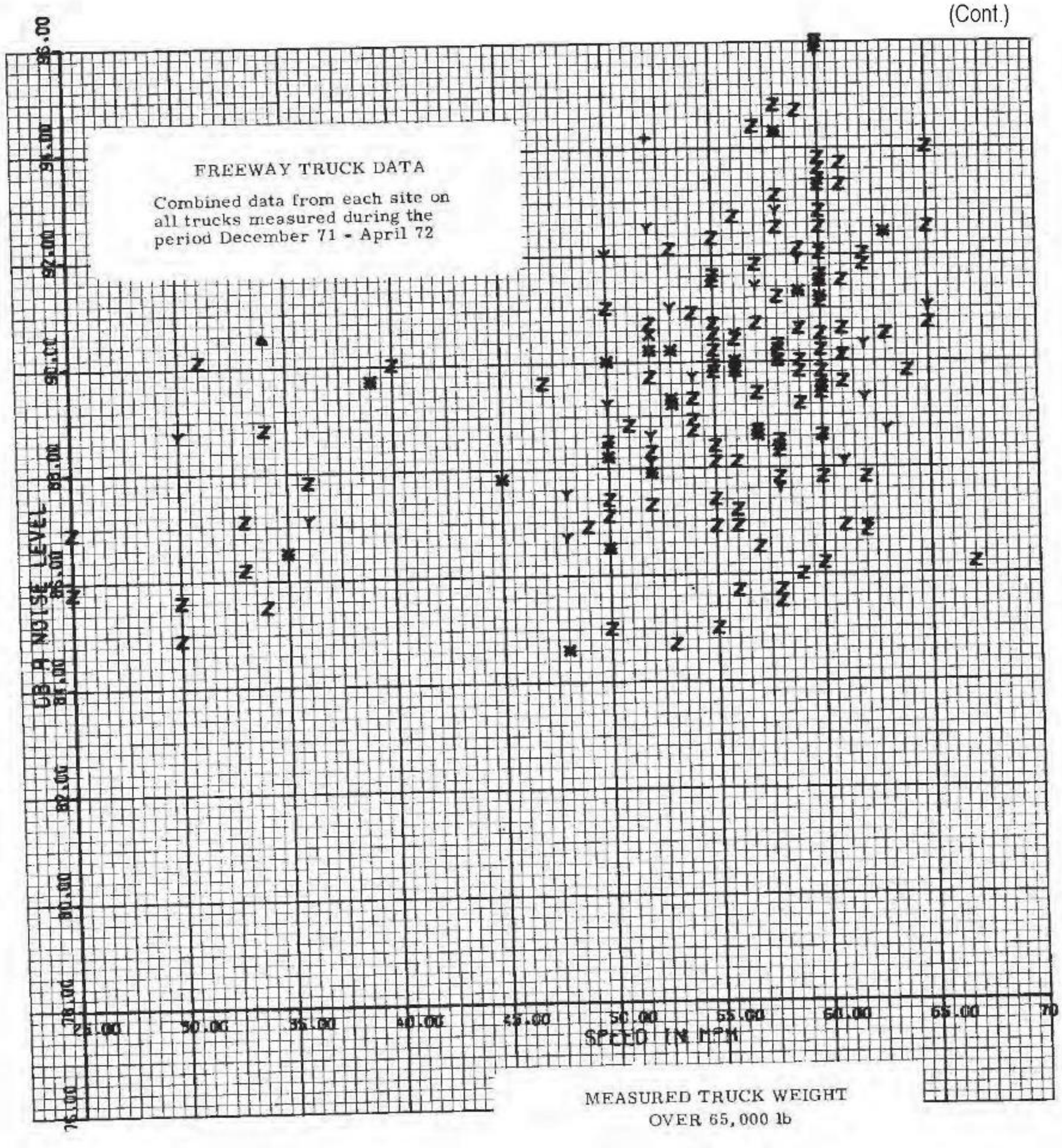

FIGURE 27.

32

Auguscik-25 (Cont.)

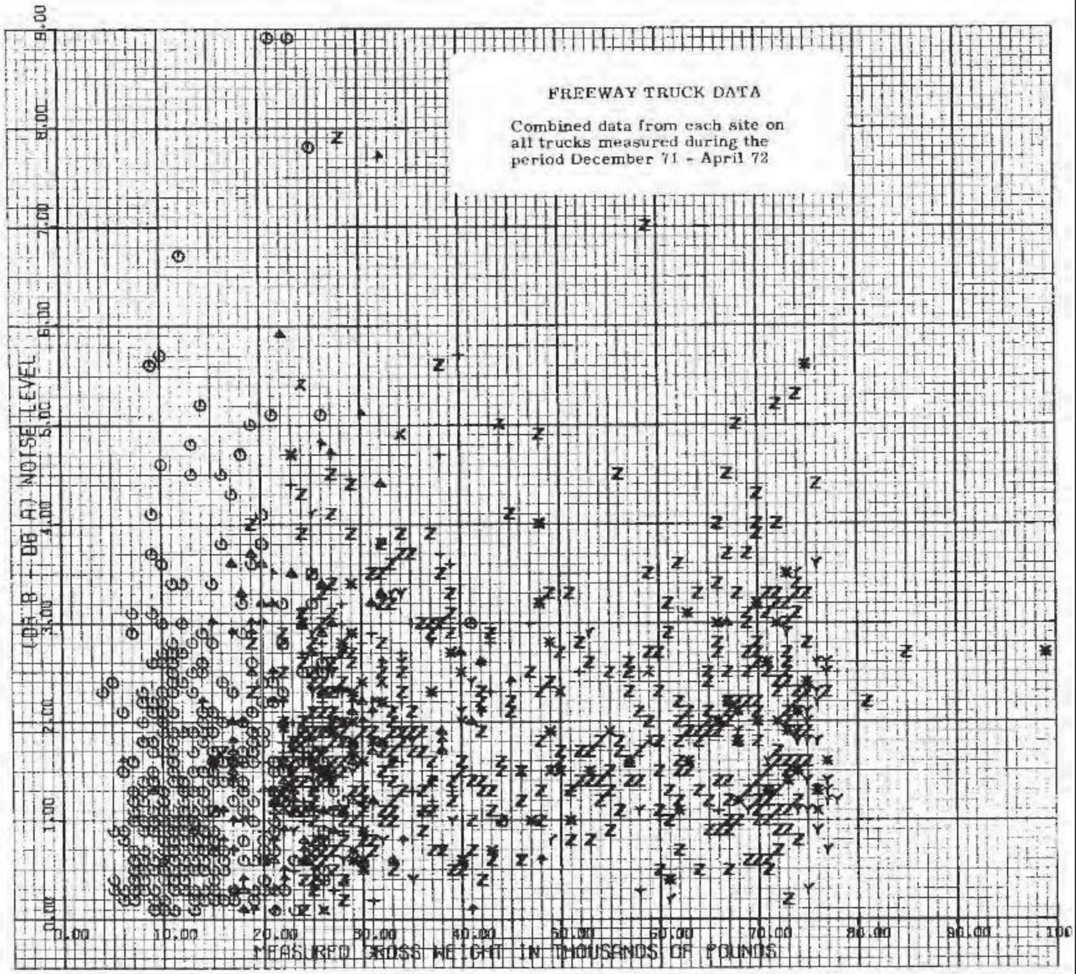

FIGURE 28.

33

Auguscik-25 (Cont.)

Figure 29 is similar to Fig. 28 except that the dBB minus dBA differences are plotted against truck speed rather than gross weight. A further question might now arise: is it predominantly the trucks which are very noisy overall that show up poorly on Fig. 28? This is answered in Figs. 30 through 33, which are plots for several of the sites in which the dBB minus the dBA level is plotted against the noise level in dBA. If only the noisier trucks had the stronger low-frequency component, these plots would show an increasing trend in dBB minus dBA as the dBA value increases. Examination of these figures shows that this is not true. The highest levels of dBB minus dBA were obtained in the mid-range of dBA values, i.e., in the region between 84 and 88 dB. The reason the quiet trucks do not show high values of dBB minus dBA is that they are quiet because they are well muffled (in addition to other noises being low), and effective muffling reduces the low-frequency noise. On the other hand, some very noisy trucks do not show high values of dBB minus dBA because they are very noisy in other respects, and this tends to drown out the low-frequency exhaust noise.

Figure 34 contains four cumulative frequency plots; one is the cumulative frequency plot for all of the trucks and is a duplicate of Fig. 14, and the other three are plots for three different weight categories ("all trucks" divided into three categories"). One category is for a measured weight less than 15,000 lb, the second between 15,000 and 30,000 lb, and the third for over 30,000 lb. In these plots the cumulative frequency of 50%, where half of the trucks are above and half are below, for trucks of 15,000 lb or less occurs at 84 dBA. For trucks between 15,000 and 30,000 lb, the 50% cumulative frequency occurs at 86 dBA (remember, for "all trucks" it occurs at 86.5 dBA), and for trucks weighing more than 30,000 lb the reading is slightly under 89 dBA. Or, if one picks a particular noise level, one can see what percentage of the trucks in the various classes would be noisier than that level. For example, if you chose 88 dBA, the charts show only 37% of the large vehicles are quieter than that value, 66% of the whole truck sampling population is quieter than that value, 75% of all the trucks between 15,000 and 30,000 lb are quieter than that value, and 88% of all the trucks weighing less than 15,000 lb are below 88 dBA.

The data plotted in Fig. 34 include trucks of all speeds. Since the slow ones are known to be less noisy, one might ask--to what degree do the slower trucks lower the "total" noise level? This is answered in Figs. 35 through 37 where only data on heavy, full-speed vehicles are included. Figure 35 is the histogram and Fig. 36 is the cumulative plot. Figure 37 shows two cumulative frequency plots, one for all (1,433) trucks that were measured on the highways, and one for only big, heavy, fast-moving trucks, of which there were 344 as shown in Fig. 36. Specifically, these were the trucks which weighed more than 30,000 lb and were traveling faster than 50 mph. The full-speed, heavy vehicles are indeed noisier than "all trucks."

Auguscik-25
(Cont.)

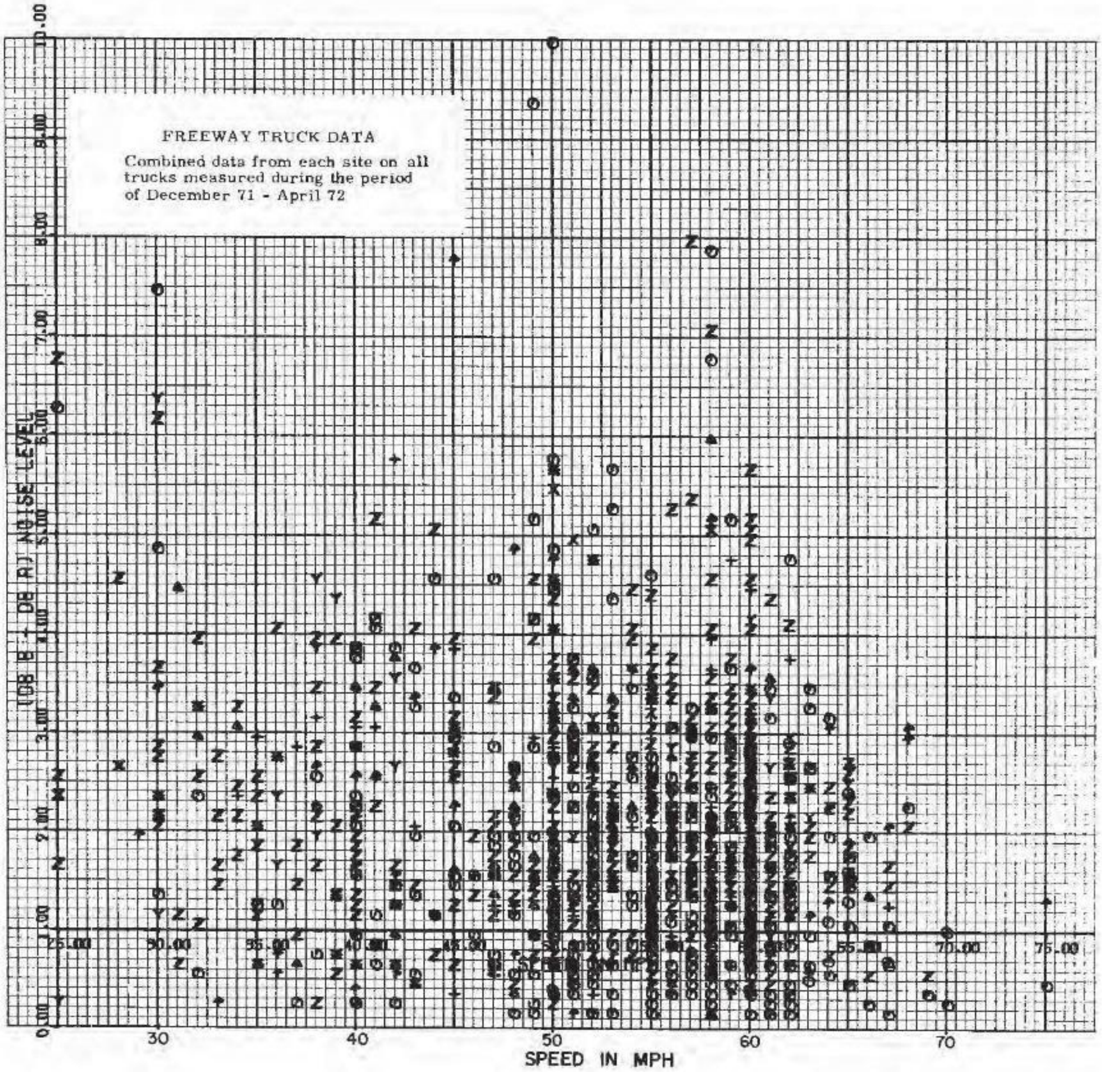

FIGURE 29.

35

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(Cont.)

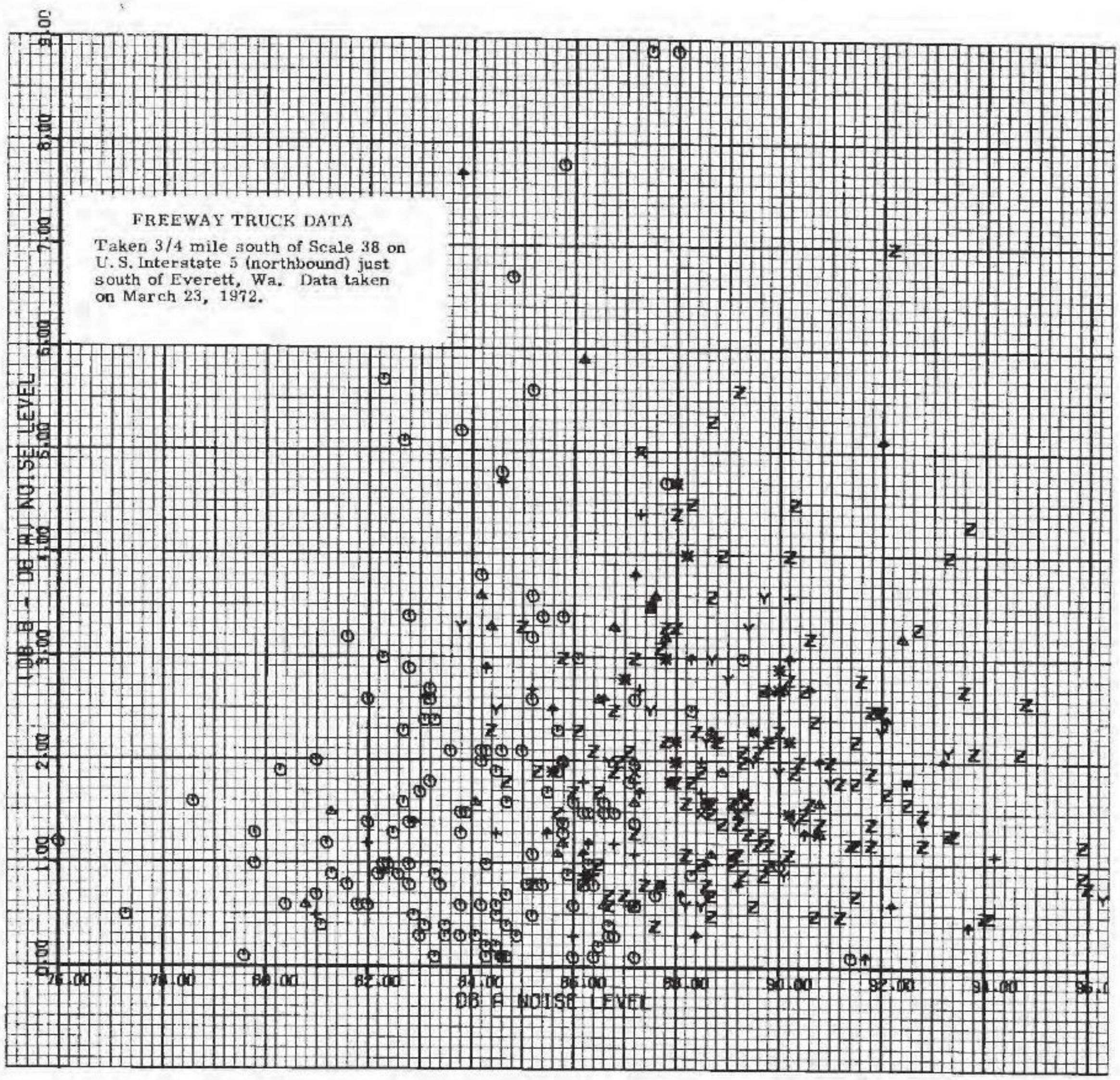

FIGURE 30.

36

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(Cont.)

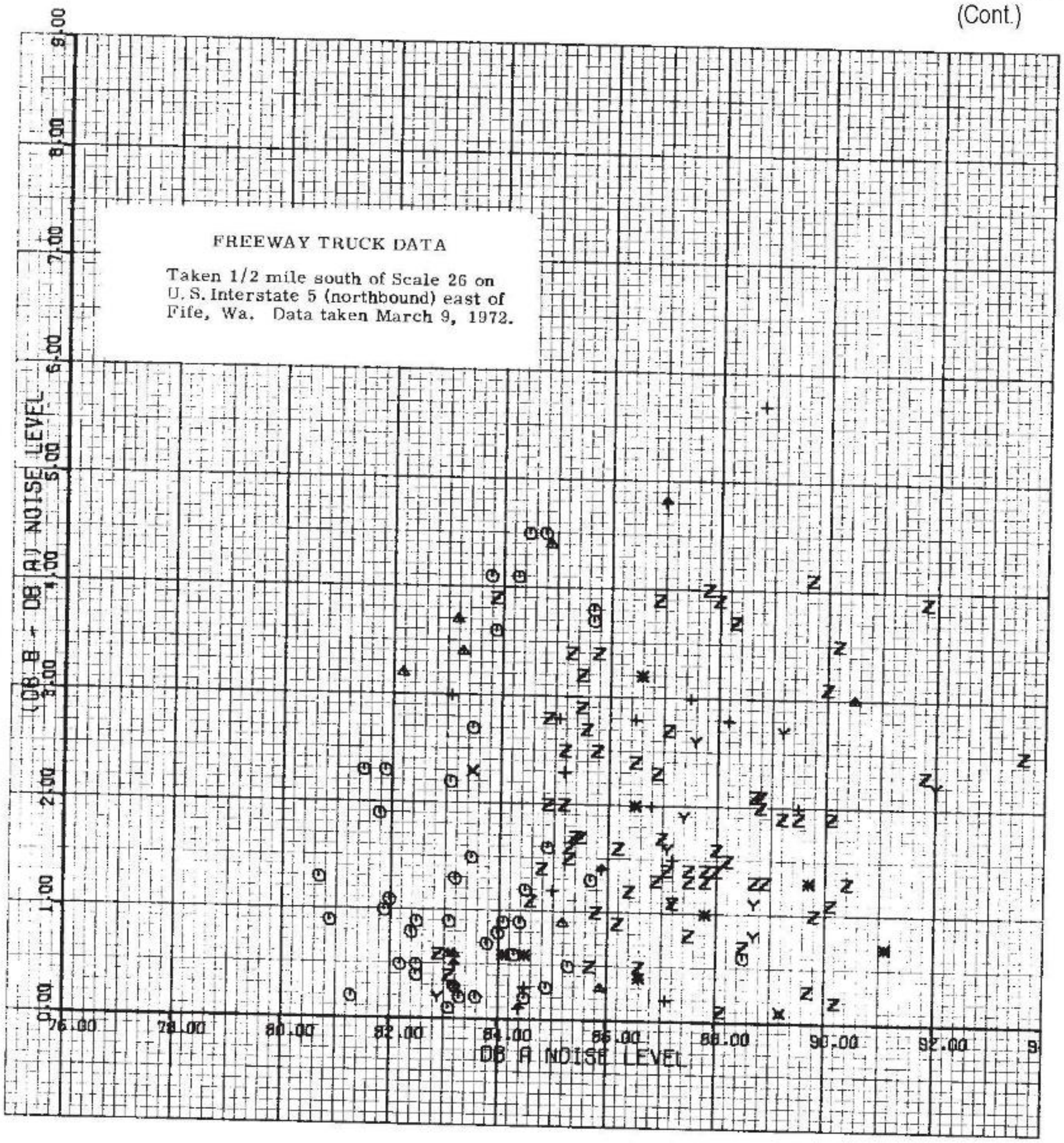

FIGURE 31.

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(Cont.)

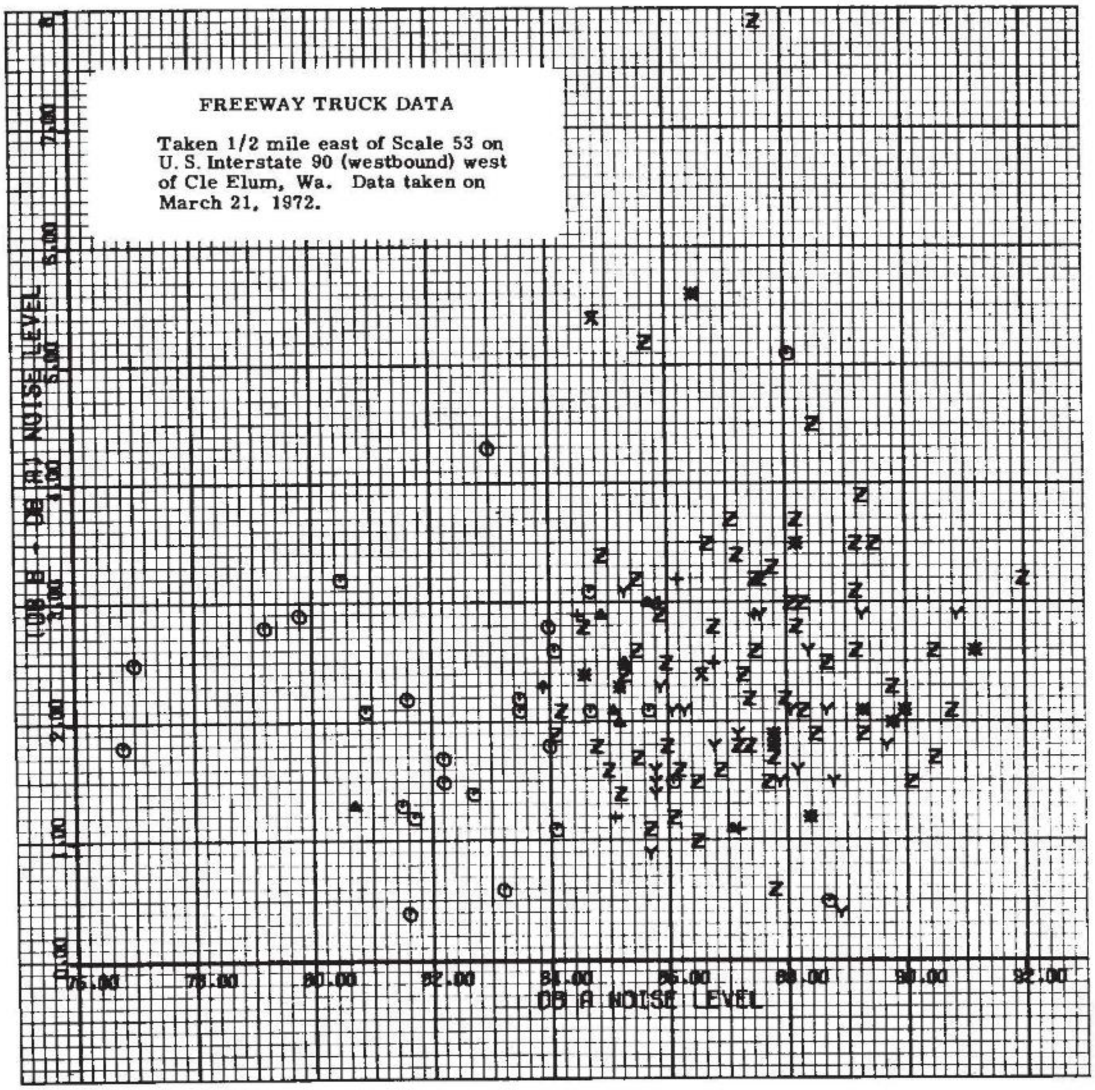


FIGURE 32.

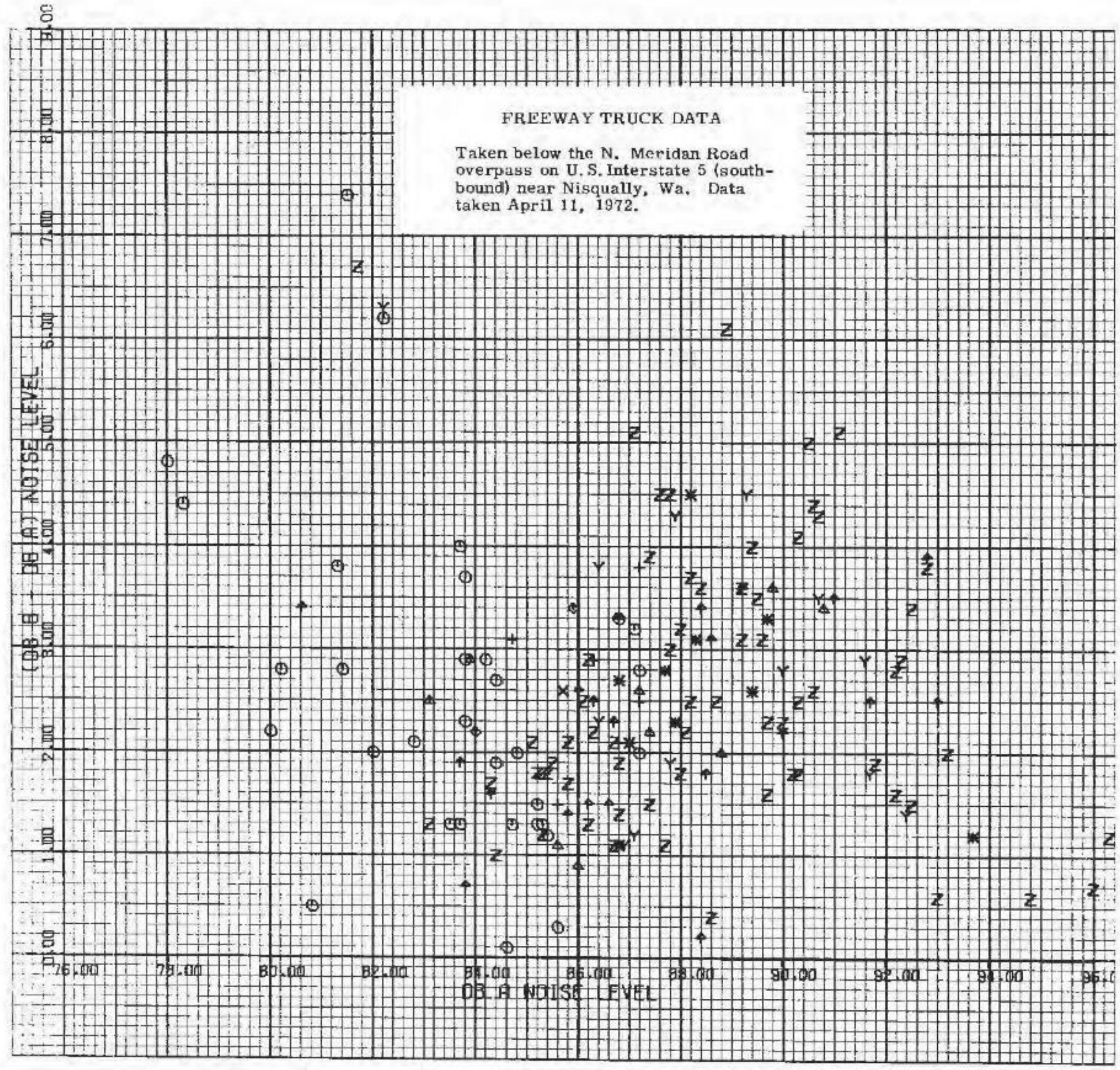

FREEWAY TRUCK DATA
Taken below the N. Meridan Road overpass on U.S. Interstate 5 (southbound) near Nisqually, Wa. Data taken April 11, 1972.
(DB B - DB A) NOISE LEVEL
DB A NOISE LEVEL

FIGURE 33.

39

Auguscik-25
(Cont.)

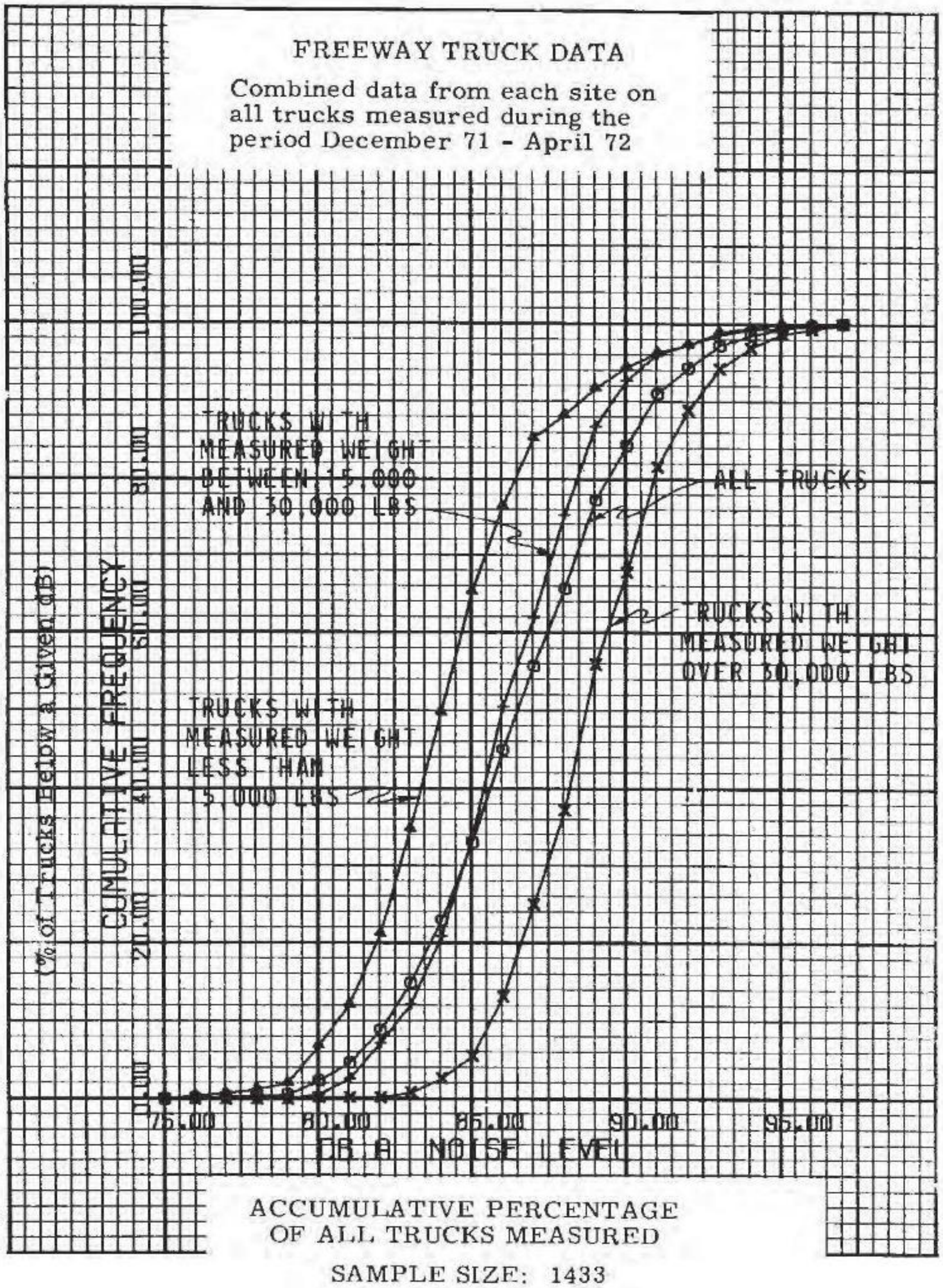


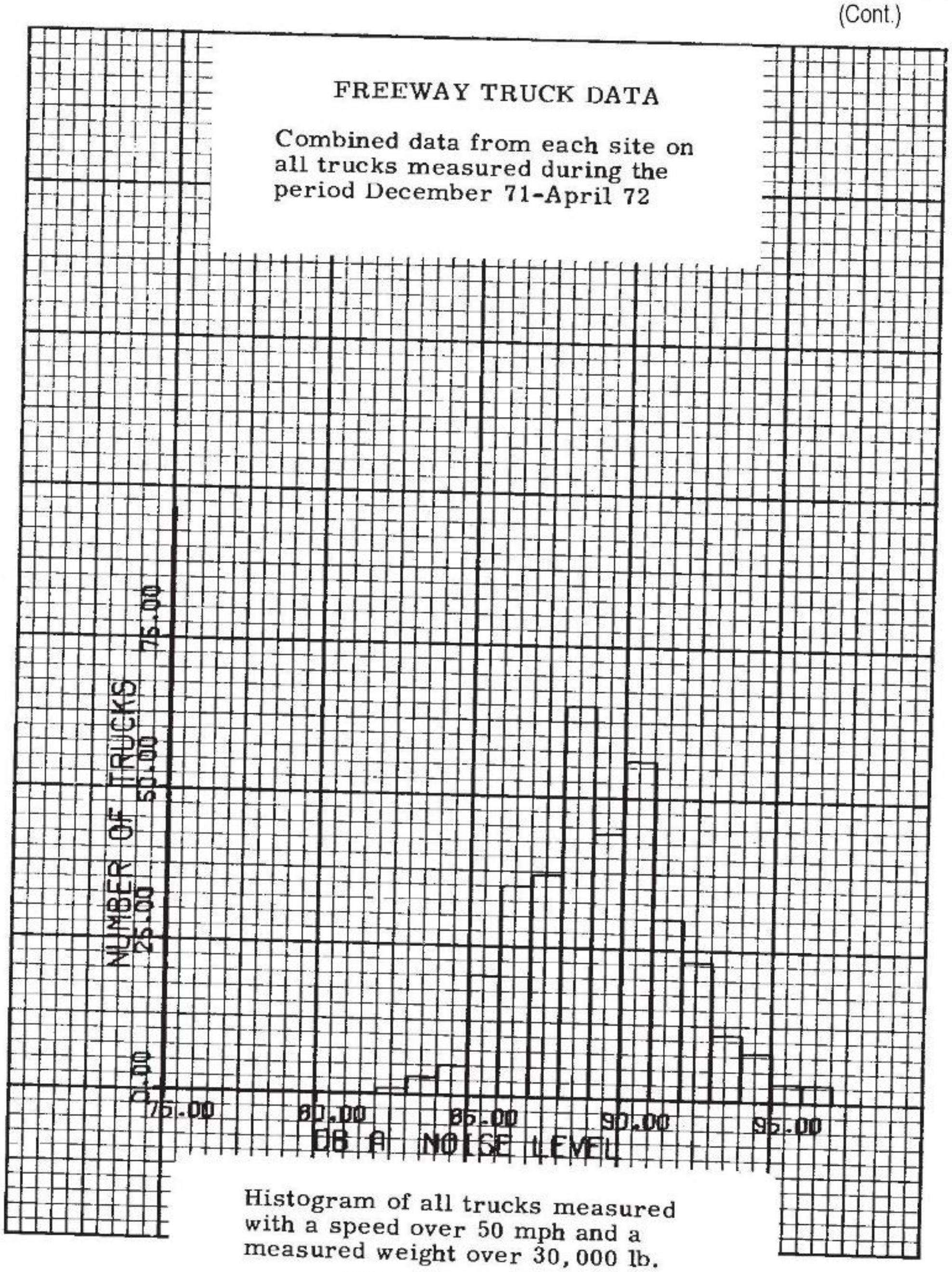
FIGURE 34.

40

Auguscik-25
(Cont.)

FREEWAY TRUCK DATA

Combined data from each site on all trucks measured during the period December 71-April 72



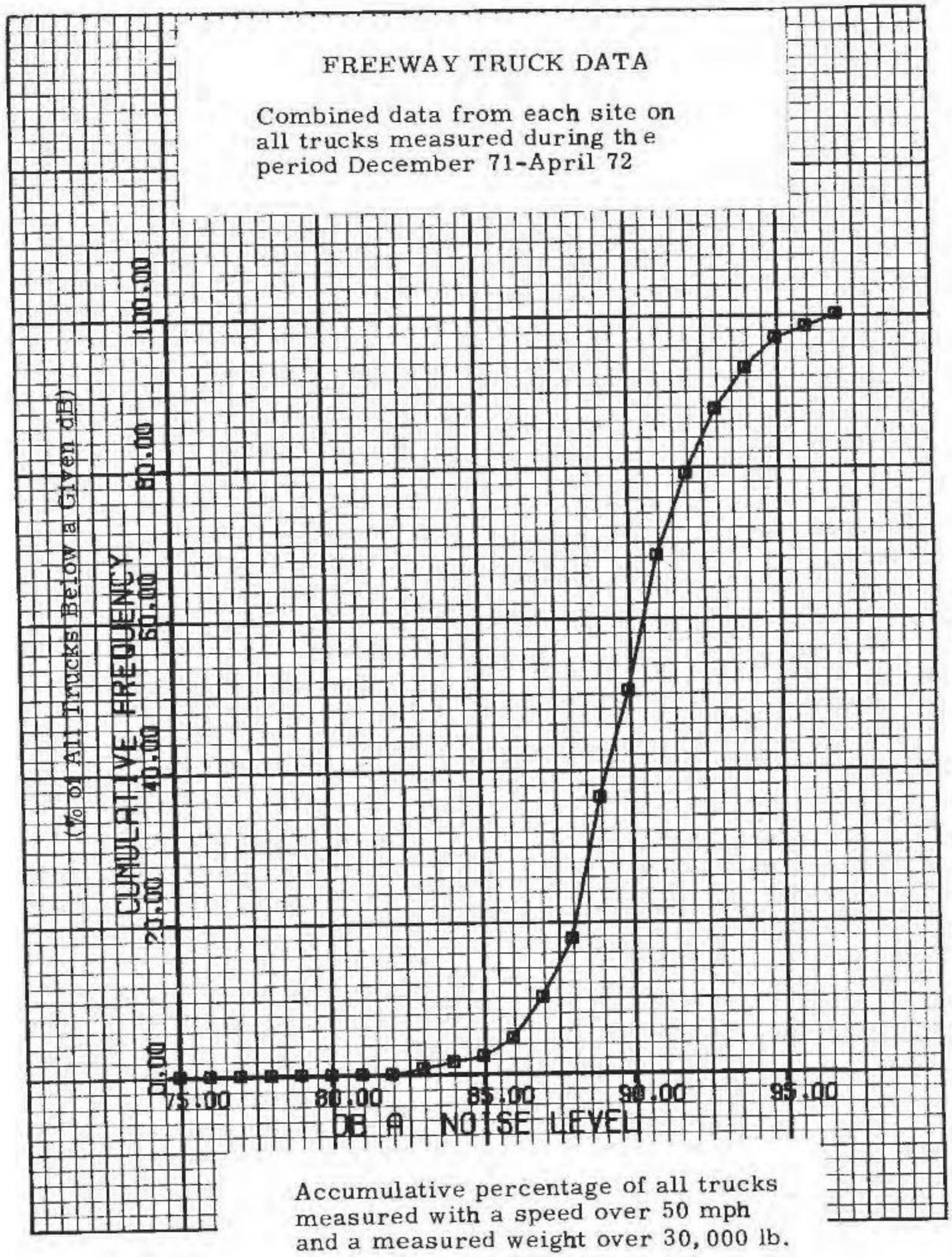
Histogram of all trucks measured with a speed over 50 mph and a measured weight over 30,000 lb.

SAMPLE SIZE: 344

FIGURE 35.

41

Auguscik-25
(Cont.)



SAMPLE SIZE: 344

FIGURE 36.

42

Auguscik-25
(Cont.)

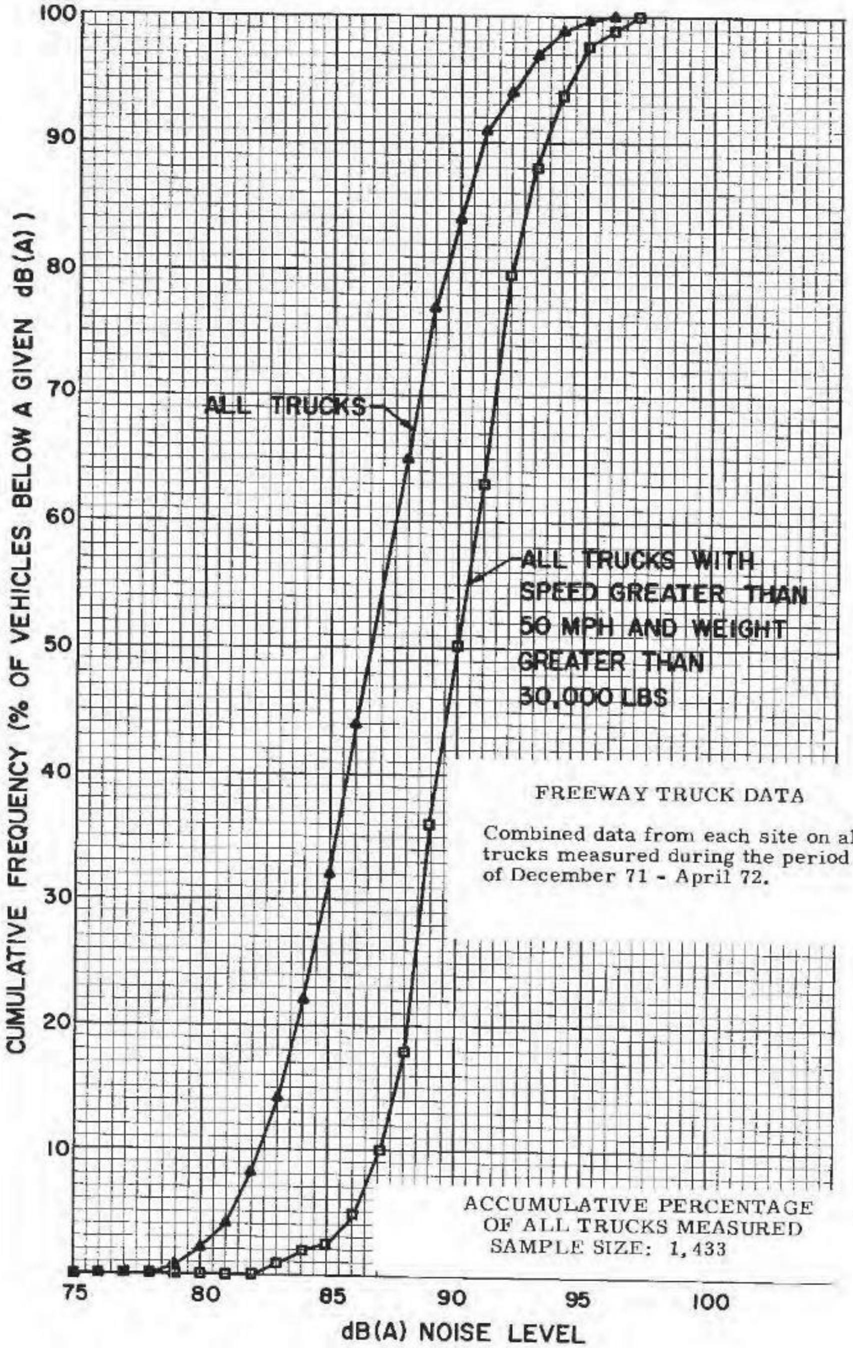


FIGURE 37.

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DISCUSSION

Table I is taken from Fig. 37 for six specific dBA noise levels. The first column in this table lists six possible maximum noise levels that could be enacted into law as the maximum dBA level at 50 ft for a truck traveling on a freeway. The second column shows the percentage of trucks now on the road which would be in compliance with such a law without needing improvements to their equipment. The third column lists the percentage of heavy, full-speed vehicles which would be in compliance with the limits given in the first column.

TABLE I.

Max. dBA of hypothetical noise control law	Percentage of vehicles now quieter than limits	Percentage of heavy, full-speed trucks now quieter than limits*
94	99	93
92	94	80
90	84	50
88	65	18
86	44	5
84	22	2

*Measured gross weight over 30,000 lb and speed greater than 50 mph

As shown in Table I, if the law allows 94 dBA, 99% of the trucks now on the highway would comply and only 1% would be in violation with excessive noise. At this maximum 94 dBA level, 93% of the heavy, full-speed trucks would be legal. Ninety-four dBA is very noisy, and, as the curve shows, enacting legislation with this limit would be virtually tantamount to no legislation at all since the overwhelming majority of trucks are already below it. If the level were set at 92 dBA, 94% of the trucks would pass and 80% of the heavy, full-speed trucks would pass. If the level were set at 90 dBA, which is the current California limit, 84% of all trucks would pass such a requirement and 50% of the big trucks going full speed would pass. If the level were set at 88 dBA, which is the next step down in the California law, 65% of all existing trucks would pass and 18% of the big, heavy, full-speed trucks would pass. If the level were set at 86 dBA, 44% of all trucks would pass and 5% of the big trucks going full speed would pass. Finally, if the level were set at 84 dBA, which is probably the lowest feasible level (considering current technology), about 22% of all existing trucks would pass this requirement and about 2% of the big, heavy, full-speed ones would pass.

A number of comments are in order concerning this Table.

Auguscik-25 (Cont.)

1. Even at the comparatively low level of 84 dBA, there are on the roads today a small number of trucks weighing over 30,000 lb and traveling in excess of 50 mph which meet this limit. This clearly shows that this level is not only technologically feasible but that it can be achieved with commercial equipment now, here, today.

2. These data were taken on audio/video tape so that data on the very quiet or very noisy vehicles could be rechecked to make absolutely certain that there were no reading or transcribing errors involved for these extrema. We have rechecked our data, and it is correct and valid.

3. The scope of our contract is not large enough to allow us to investigate exactly what features of these trucks make them quiet. However, it seems certain that a fortuitous combination of tires, transmission, engine, mufflers, and maintenance practices enabled these trucks to show such good performance. Auguscik-25 (Cont.)

4. Although the data clearly show that a level of 84 dBA is actually achieved by some trucks at present, it also shows that there are few big trucks which do so--and it would probably be a considerable strain on the trucking industry to require all trucks to meet such a low level now, particularly since they would not know precisely what to do to their trucks to bring them to this level. Obviously, more research has to be done to find out what changes can be made in truck design--hopefully, in the area of alterations to existing trucks as well as in the manufacture of new trucks--to bring them down to this level. I think that the 84 dBA level will ultimately be written into the statutes; perhaps, in time, even lower levels will be reasonable.

5. At the other end of the scale, it would not seem worthwhile to pass a law which would be any less effective than the California law, which has been 90 dBA for trucks traveling over 35 mph. This level will be reduced to 88 dBA in California in the near future (see Appendix F).

We have already seen that there is some noise correlation with speed; that is, the faster the vehicles go, the noisier they become. (As a matter of fact, for automobiles, at least, the noise power is probably proportional to the cube of speed.) We have also seen that the heavier the vehicles are, the more likely they are to be noisier. An appropriate question arises--is this increase in noise with weight always associated with the total weight of the truck or does the percentage of full load enter into the picture? For example, in a fully loaded, 30,000 lb truck, is it the load that causes it to be noisy or would a large truck running empty at that same weight be equally noisy? Figure 38 sheds some light

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on these questions. It uses data from the Everett site and is a plot of the dBA level versus the percentage of full load. Since most trucks have a decal or lettering indicating the licensed gross weight and we were able to determine their actual weight at the weighing station, we could compute the percentage of full load. Figure 38 plots this percentage level against the noise level. Note that this plot includes data which exceed 100%; there were vehicles that were overloaded by as much as 20%. Probably the most significant feature of the chart is that there does not seem to be any real correlation between the noise of the truck and the percentage of full load. Together with the other information in the report, this clearly shows that actual total weight is important, whereas the percentage of full load is not.

As shown in Fig. 38, some vehicles were overloaded, and in the Appendices (which give more complete data on the individual sites) it is obvious that some trucks were exceeding the 60 mph speed limit. The question then arises--just how much do these trucks, which are violating one or both of these regulations, add to the overall noise curves for trucks in general?

Auguscik-25 (Cont.)

Figure 39 addresses itself to this question. It uses Everett data taken in the wintertime. There are two plots on this figure: one is a cumulative frequency plot for all of the trucks taken at Everett during the wintertime, and the other shows the same data after those trucks exceeding 62 mph and 101% of licensed gross weight have been eliminated. Note that the cumulative noise curve is slightly reduced. The effect, however, for this particular case is not large. At the 50% cumulative frequencies there is only about 0.5 dB difference between the two curves. Therefore, 100% strict enforcement of the speed and weight regulations cannot be regarded as a method for significantly quieting vehicle noise on the highways.

One question that might be asked is what would be the effect of removing from the road all those vehicles which have a high dBB minus dBA reading, which we interpret to mean, in most cases, that they are poorly muffled vehicles? Figure 40 answers this, again using wintertime Everett data. There are four plots on this curve: one is the regular cumulative frequency curve for this site; the second plot is the same curve but with all trucks whose dBB minus dBA is in excess of 3 dB deleted; the third curve is the same but it deletes even more trucks--those in excess of 2 dB; and, finally, a curve which eliminates those with a difference in excess of 1 dB. These deletions produce a quieter cumulative frequency curve, but not by a large amount. At the 50% point, eliminating all those above the 3 dB difference reduces the curve about 0.5 dB; eliminating all those above 2 dB reduces the curve by a little over 1 dB; and eliminating all those above 1 dB reduces it by a little over 2 dB. These curves clearly show that truck noise problems are not going to be solved by better mufflers, and that there are other important sources of noise which occur at the frequencies to which the A-scale and human ears are sensitive. Adequate muffling of trucks is certainly the

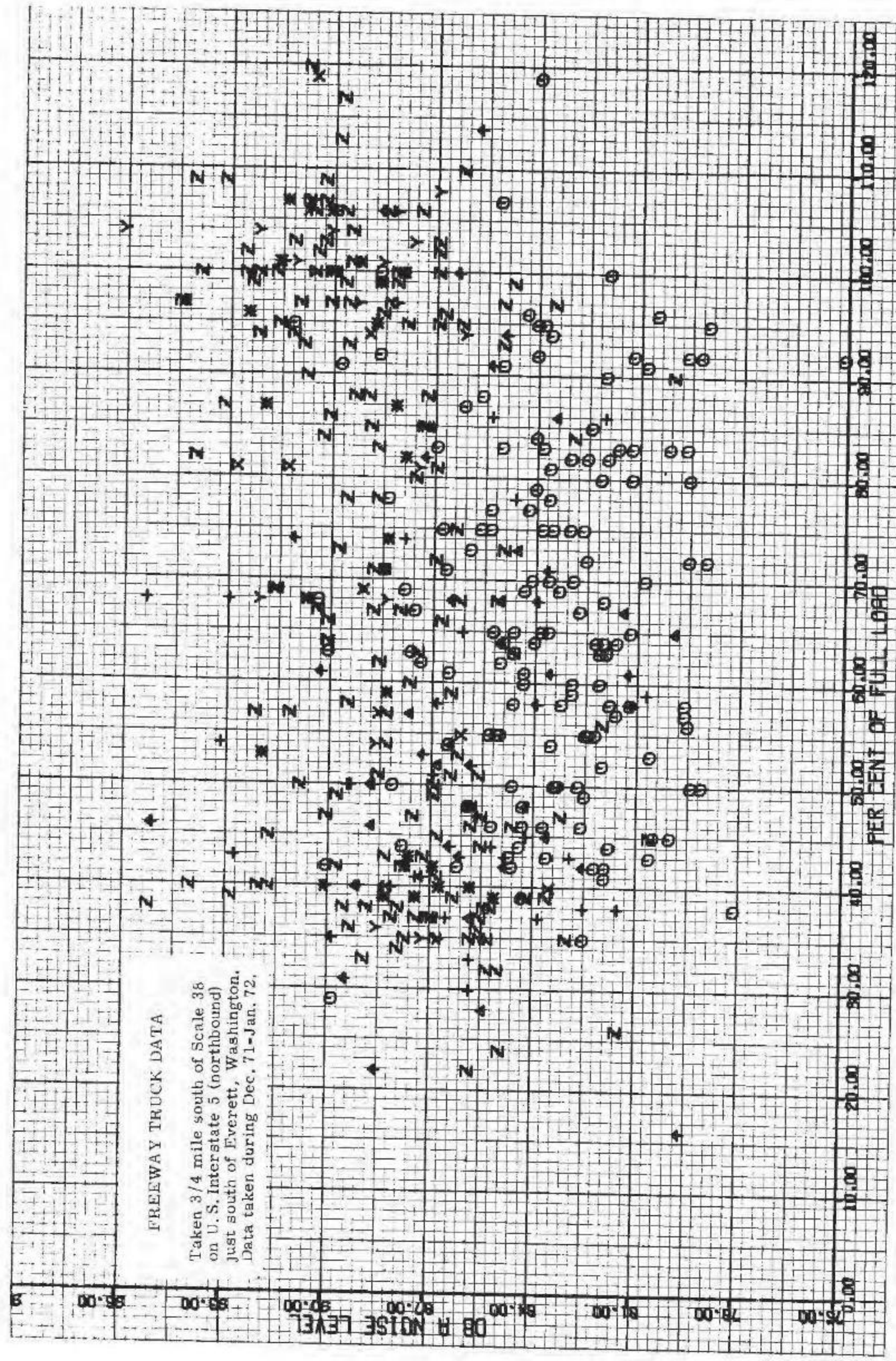
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
DB A NOISE LEVEL
PER CENT OF FULL LOAD
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
75.00
78.00
81.00
84.00
87.00
90.00
93.00
96.00

FIGURE 38.

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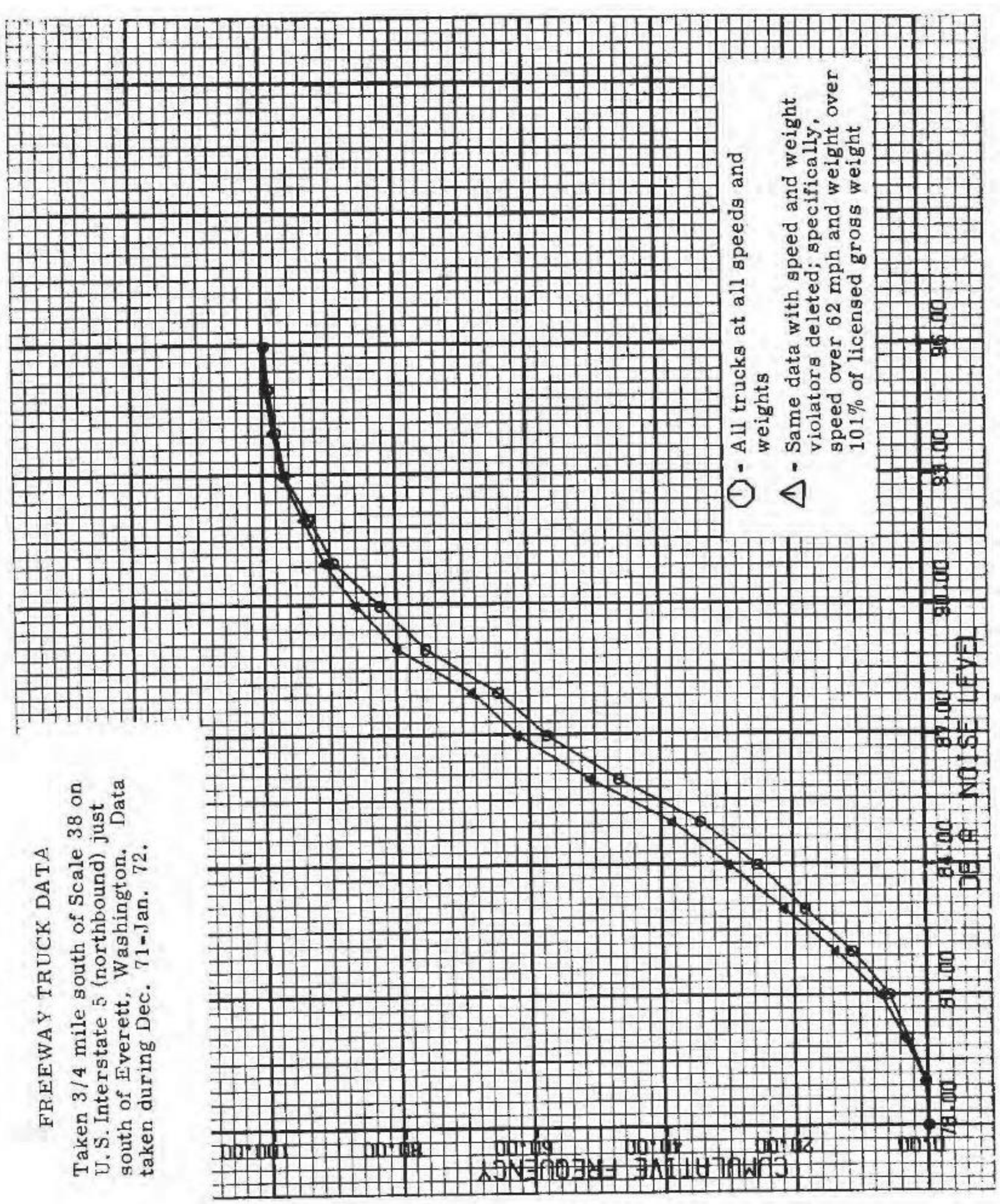
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
○ - All trucks at all speeds and weights
△ - Same data with speed and weight violators deleted; specifically, speed over 62 mph and weight over 101% of licensed gross weight
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
DB(A) NOISE LEVEL
78.00
81.00
84.00
87.00
90.00
93.00
96.00

FIGURE 39.

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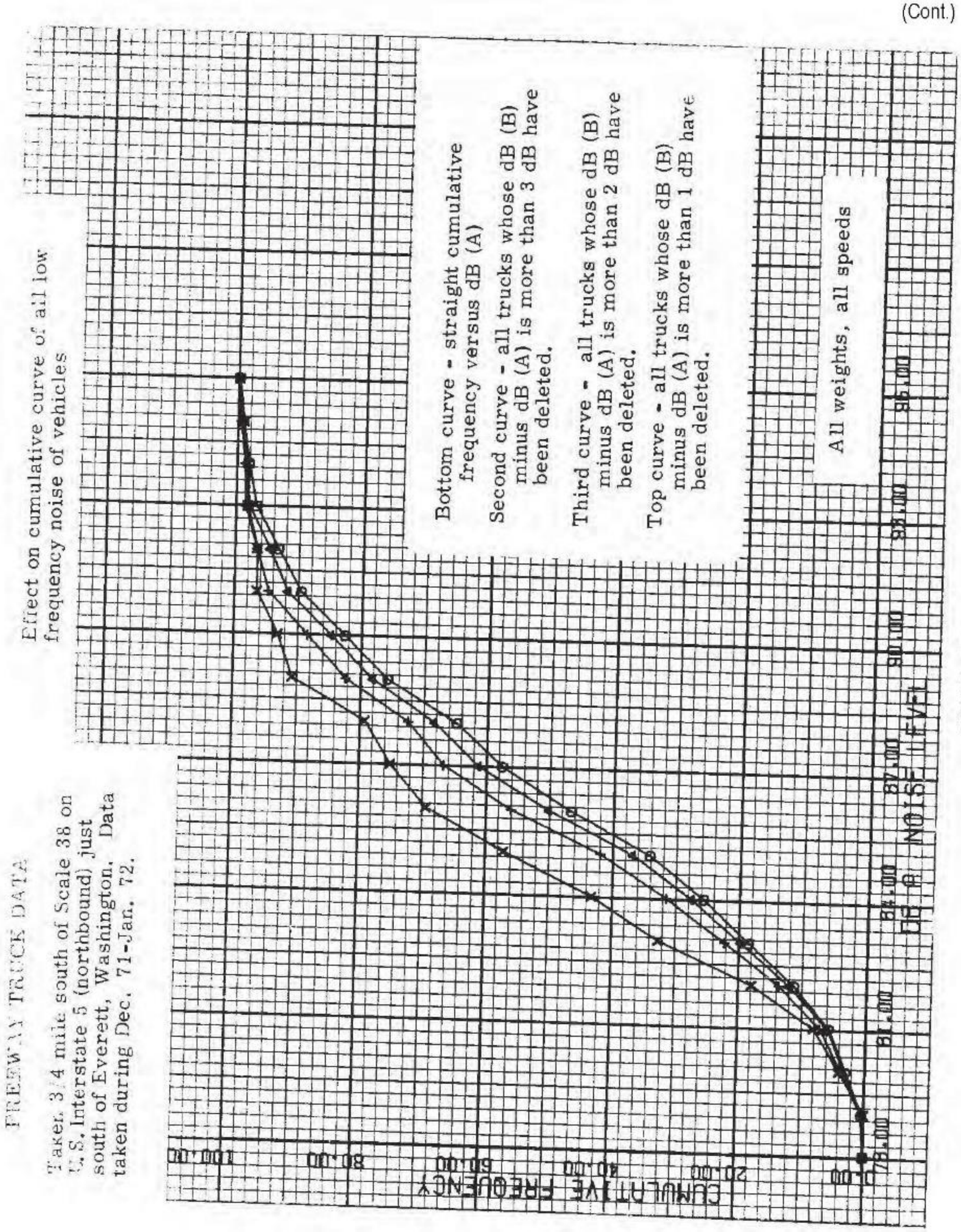
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U.S. Interstate 5 (northbound) just south of Everett, Washington. Data taken during Dec. 71-Jan. 72.
Effect on cumulative curve of all low frequency noise of vehicles
Bottom curve - straight cumulative frequency versus dB (A)
Second curve - all trucks whose dB (B) minus dB (A) is more than 3 dB have been deleted.
Third curve - all trucks whose dB (B) minus dB (A) is more than 2 dB have been deleted.
Top curve - all trucks whose dB (B) minus dB (A) is more than 1 dB have been deleted.
All weights, all speeds
CUMULATIVE FREQUENCY
100.00
80.00
60.00
40.00
20.00
0.00
DB A NOISE LEVEL
78.00
81.00
84.00
87.00
90.00
93.00
96.00

FIGURE 40.

49

first step to be taken in quieting our highways, but it should not be viewed as a panacea for truck and highway noise problems.

During some of the later data-taking stages, attempts were made to ascertain some of the makes of the trucks involved in the survey. Although we were not able to obtain the make in all cases, in many cases we were able to, and Figs. 41 through 43 present this information. Figure 41 is a plot of the dBA noise level versus gross weight of the trucks taken March 23 at the Everett site; each data point, instead of using the class symbol, uses a symbol to identify the manufacturer in accordance with the following scheme: K = Kenworth, W = White, etc., as shown in the key on each of these three figures. Figure 42 is a similar type of plot taken from Cle Elum measurements. Figure 43 is a similar plot taken from the Fife data. There is no simple, clear conclusion to be drawn from these data. The heavier trucks in this state are frequently built by Kenworth as indicated by the many K's appearing in the heavier weight category. These trucks vary from rather quiet to noisy. There are a number of White trucks which are fairly quiet, but there are also some noisy W's. I am sure these data would be of great interest to the individual truck manufacturers. It is possible to make cumulative plots from the original data cards for each of the different manufacturers and other types of analyses from the fundamental information available. However, funds are not sufficient on this particular contract to pursue this further. It is left to the reader to review these charts and form his own opinion.

Figure 44 is a histogram of the trucks measured at 6th Ave. and Hanford St. in the industrial section of Seattle. Figure 45 is a plot of the noise level of these trucks taken on this main arterial which has a 35 mph speed limit. The lower speed trucks were almost all below 90 dBA; 88% of them were quieter than 85 dBA; 57% were quieter than 80 dBA; and 27% were quieter than 75 dBA. The 50% cumulative frequency point was about 79 dBA.

Figure 46 is the histogram of automobiles measured at the Everett and Cle Elum sites. As previously mentioned, the other sites generally had too much traffic to make valid automobile measurements--the car to be measured had to be in the curb lane with no other vehicle in the other lanes at the same time. Figure 46 indicates that the most likely noise level is between 79 and 80 dBA (in this category there were 150 cars out of the sample size of 878). Figure 47 gives a cumulative frequency plot of the data shown in Fig. 46. This shows that 92% of the cars were quieter than 82 dBA; the 50% point occurred at 79.5 dBA (half of the cars were noisier than 79.5 and half were quieter); and only 10% of the cars were quieter than 76.5 dBA.

Figure 48 is a similar cumulative frequency plot but it includes only the Everett data rather than a combination of the Everett and Cle Elum measurements. These data show the 50% point about 1 dBA quieter than the combined data. The probable explanation of this is that virtually all the cars, including the high-speed ones, were in the curb

Auguscik-25
(Cont.)

lane at Cle Elum, but at Everett it was usually only the slower cars which used the curb lane. There also could be differences in the "noisiness" of the road surface at the two locations; this could be especially important for automobile data, since at these speeds tire noise predominates in most car noise levels.

Figure 49 is a plot of the Cle Elum car data where the noise level is plotted as a function of the vehicle's speed. This gives a more clear-cut correlation of the noise versus speed than was true in the case of trucks. There has been some controversy within the highway acoustic "trade" concerning the mathematical relationship between car noise and speed. These data indicate that noise power increasing with the cube of traffic speed is a better fit than increasing with the square of speed, as some advocates have proposed. This result seems reasonable since the power consumed by viscous drag in most viscous hydrodynamic systems increases with the cube of velocity.

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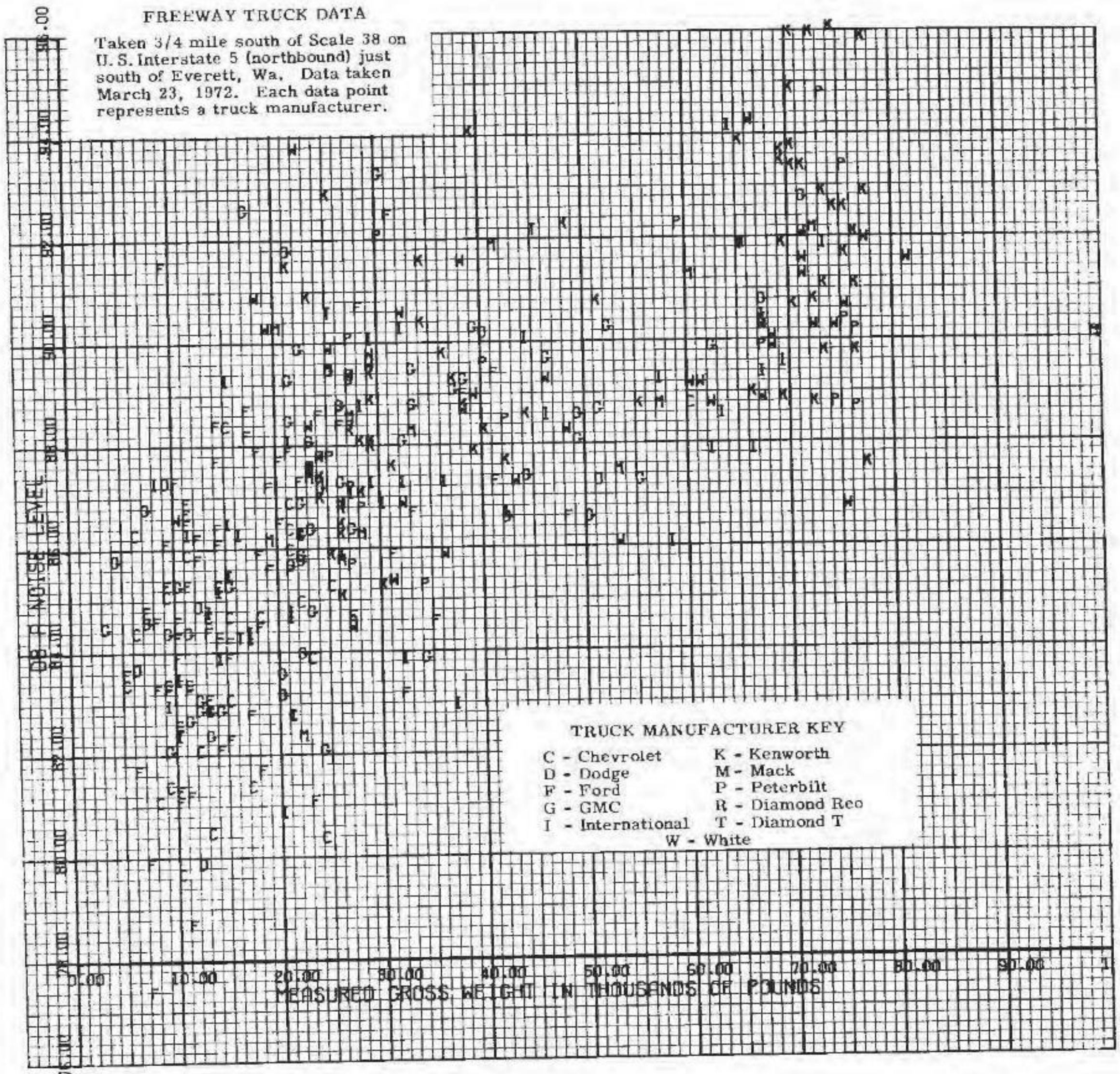
FREEWAY TRUCK DATA
Taken 3/4 mile south of Scale 38 on U. S. Interstate 5 (northbound) just south of Everett, Wa. Data taken March 23, 1972. Each data point represents a truck manufacturer.
DB (I) NOISE LEVEL
MEASURED GROSS WEIGHT IN THOUSANDS OF POUNDS
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
TRUCK MANUFACTURER KEY
C - Chevrolet
D - Dodge
F - Ford
G - GMC
I - International
K - Kenworth
M - Mack
P - Peterbilt
R - Diamond Reo
T - Diamond T
W - White

FIGURE 41.

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(Cont.)

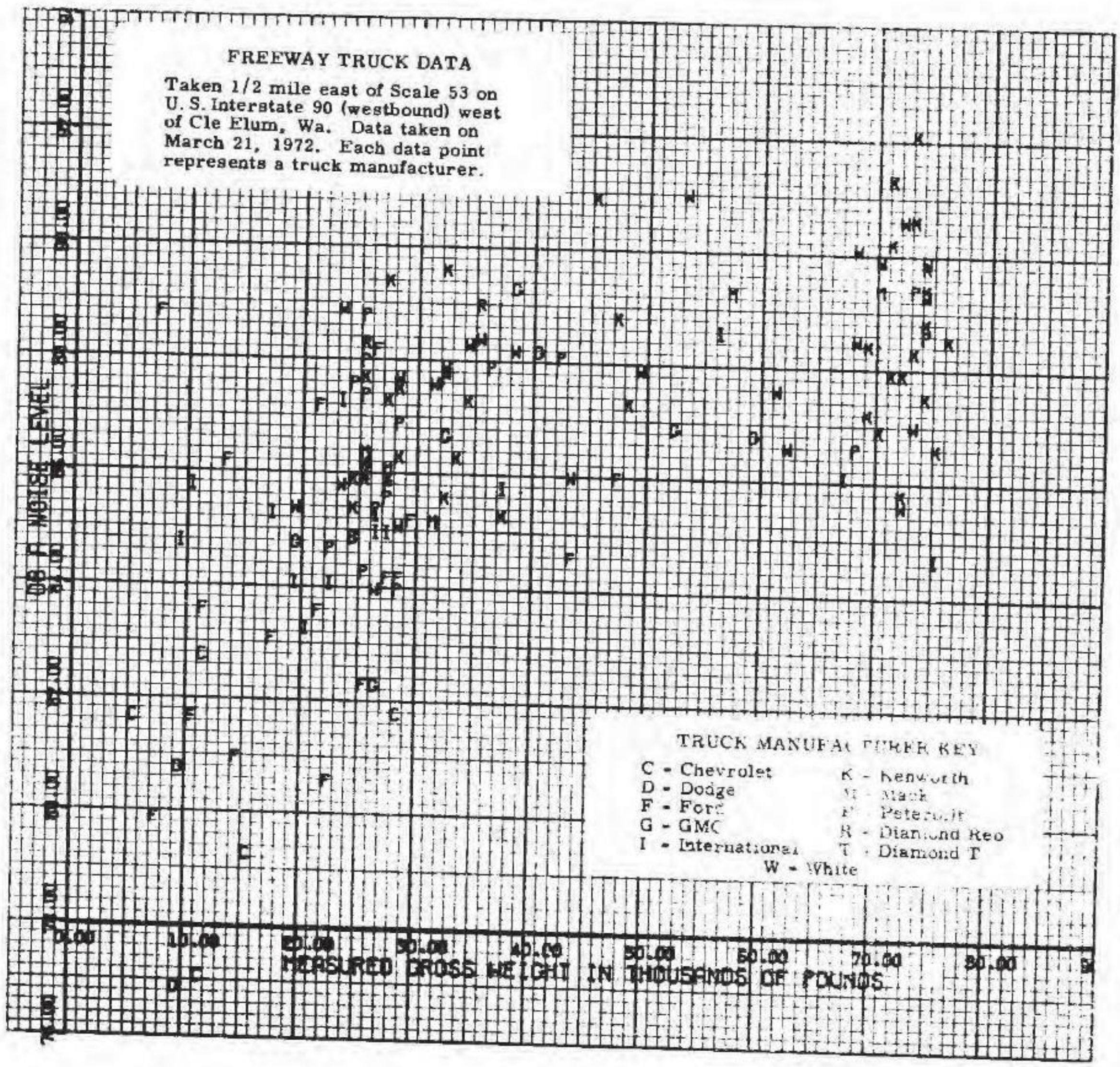

FIGURE 42.

53

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(Cont.)

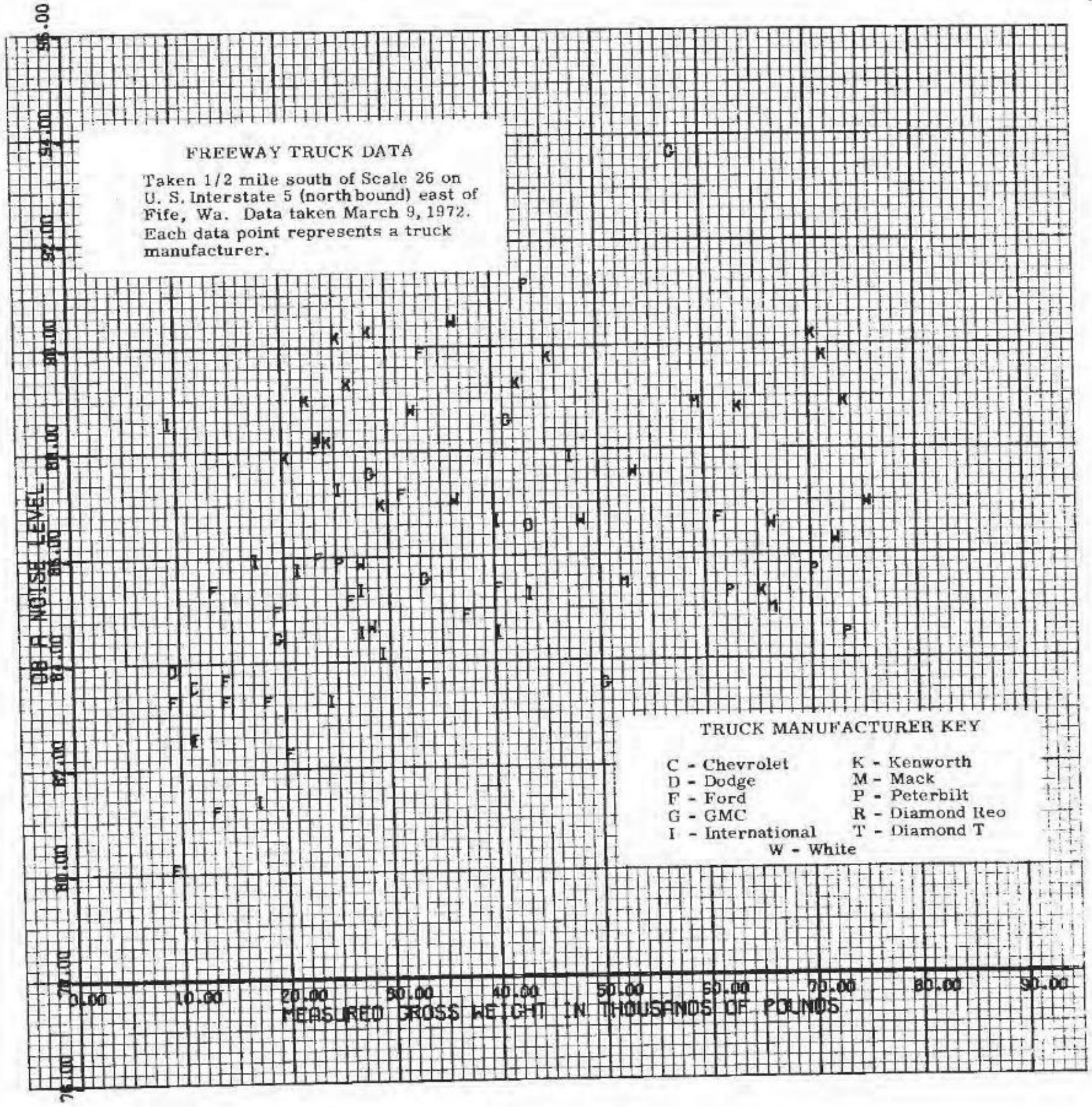


FIGURE 43.

54

Auguscik-25
(Cont.)

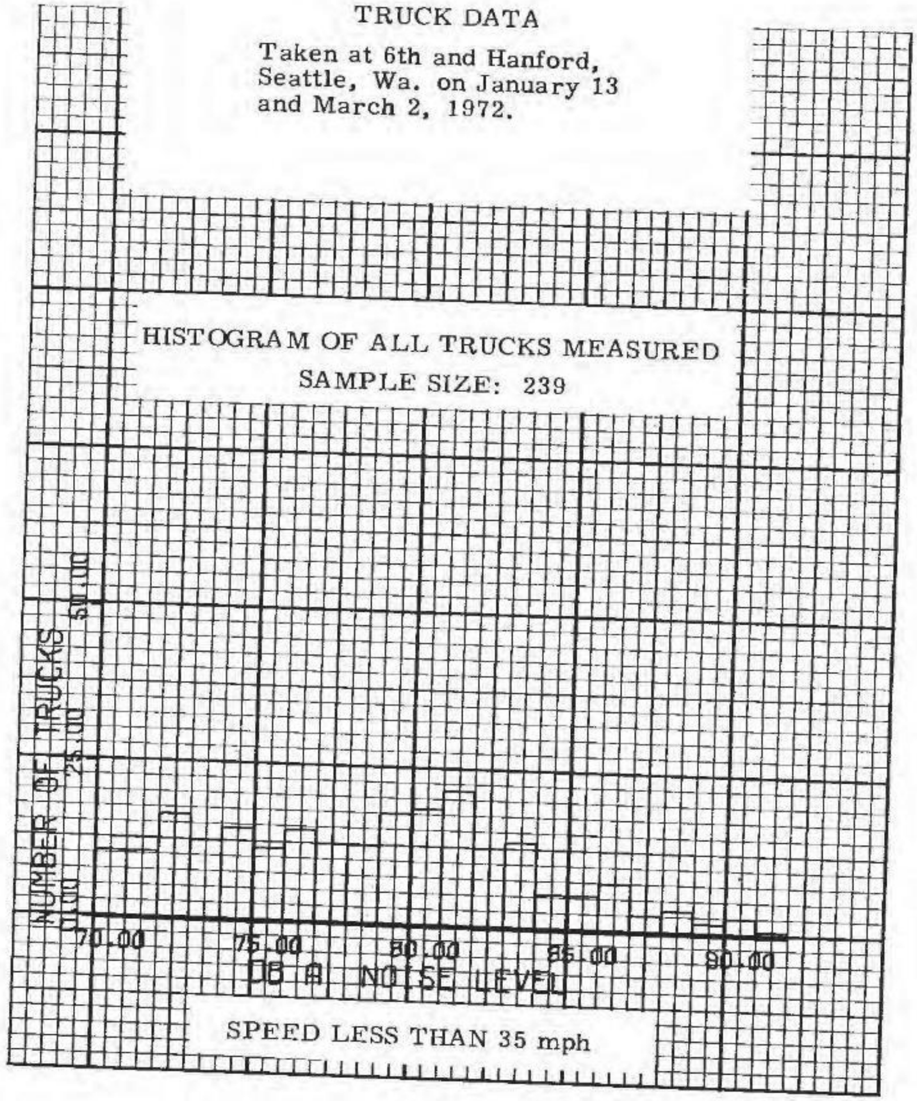


FIGURE 44.

55

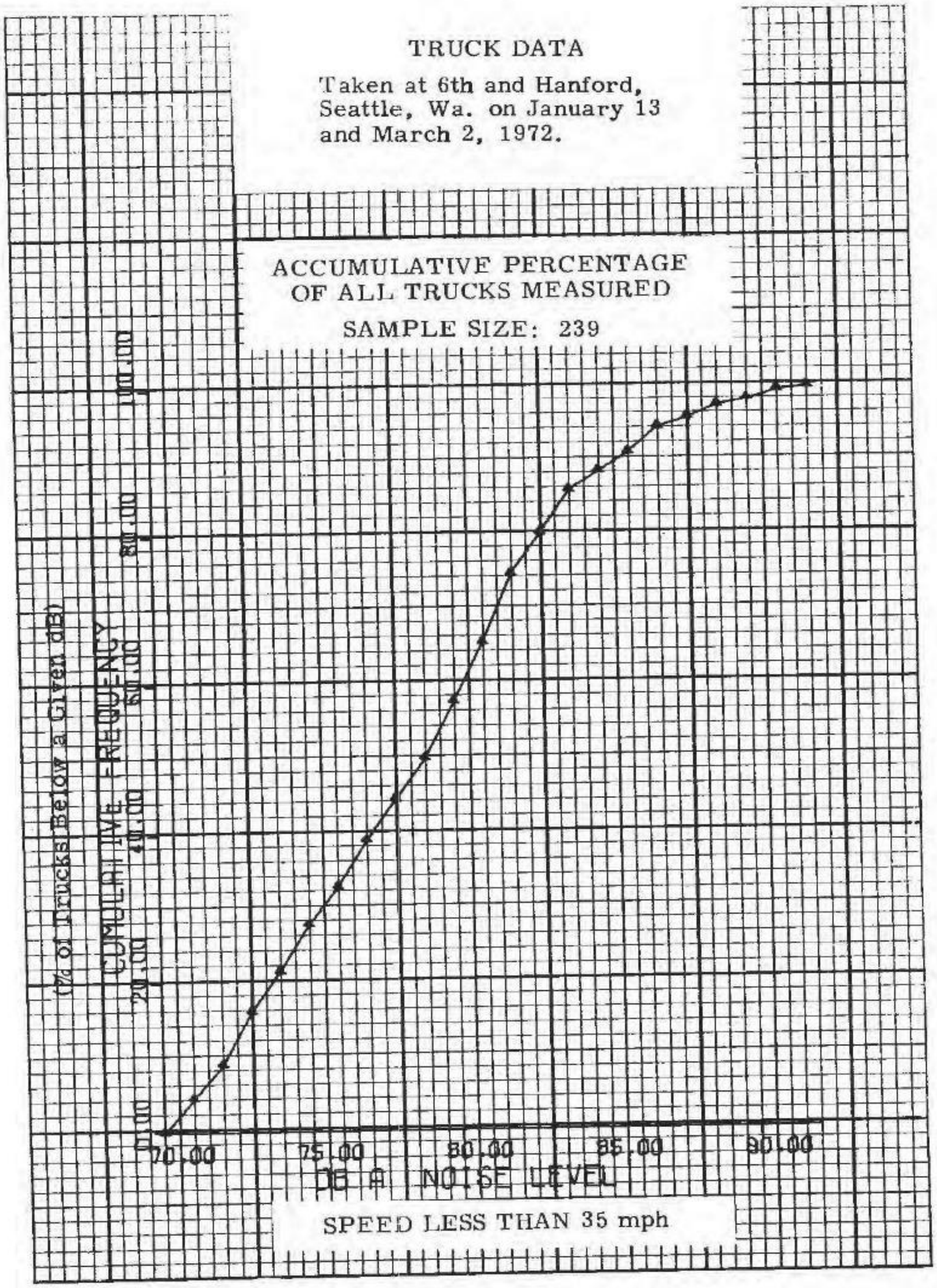
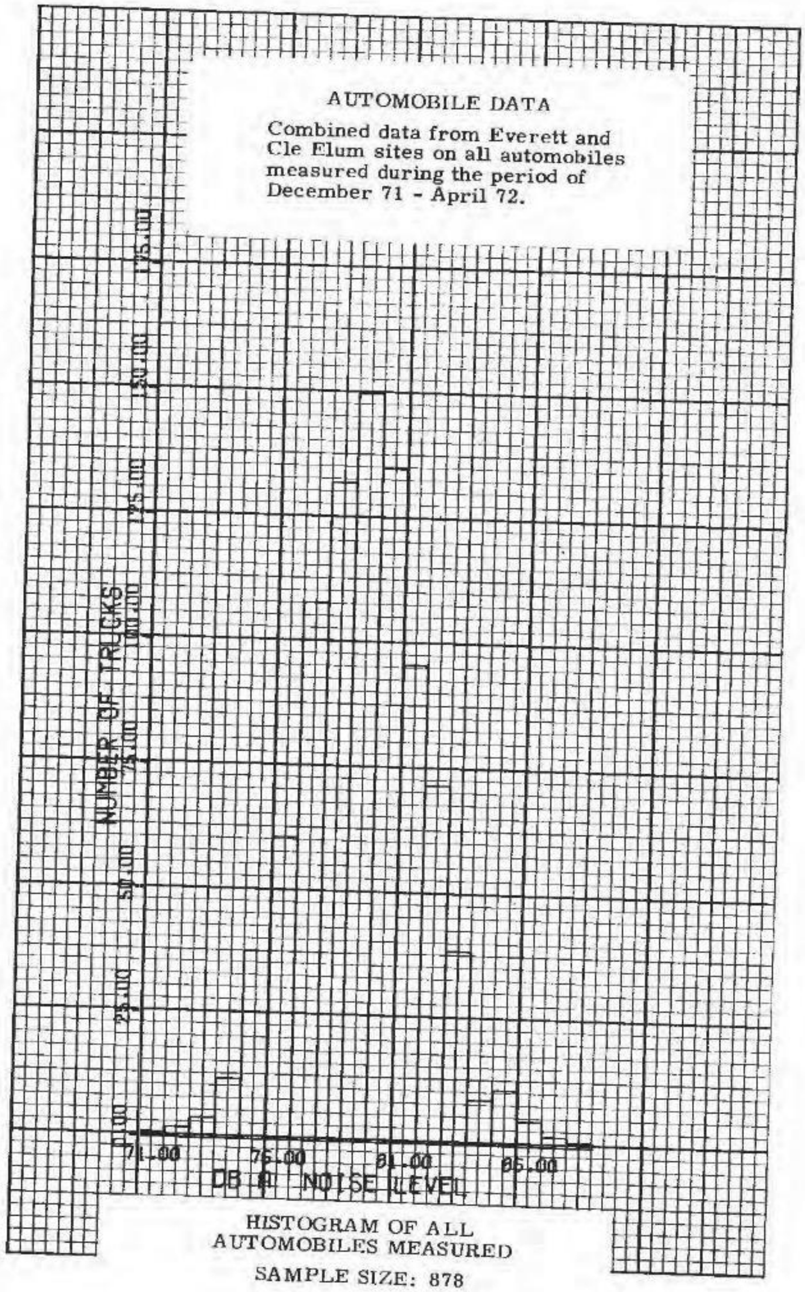

TRUCK DATA
Taken at 6th and Hanford, Seattle, Wa. on January 13 and March 2, 1972.
ACCUMULATIVE PERCENTAGE OF ALL TRUCKS MEASURED
SAMPLE SIZE: 239
(% of Trucks Below a Given dB)
CUMULATIVE FREQUENCY
0.00
20.00
40.00
60.00
80.00
100.00
70.00
75.00
80.00
85.00
90.00
DB A NOISE LEVEL
SPEED LESS THAN 35 mph

FIGURE 45.

56

Auguscik-25
(Cont.)



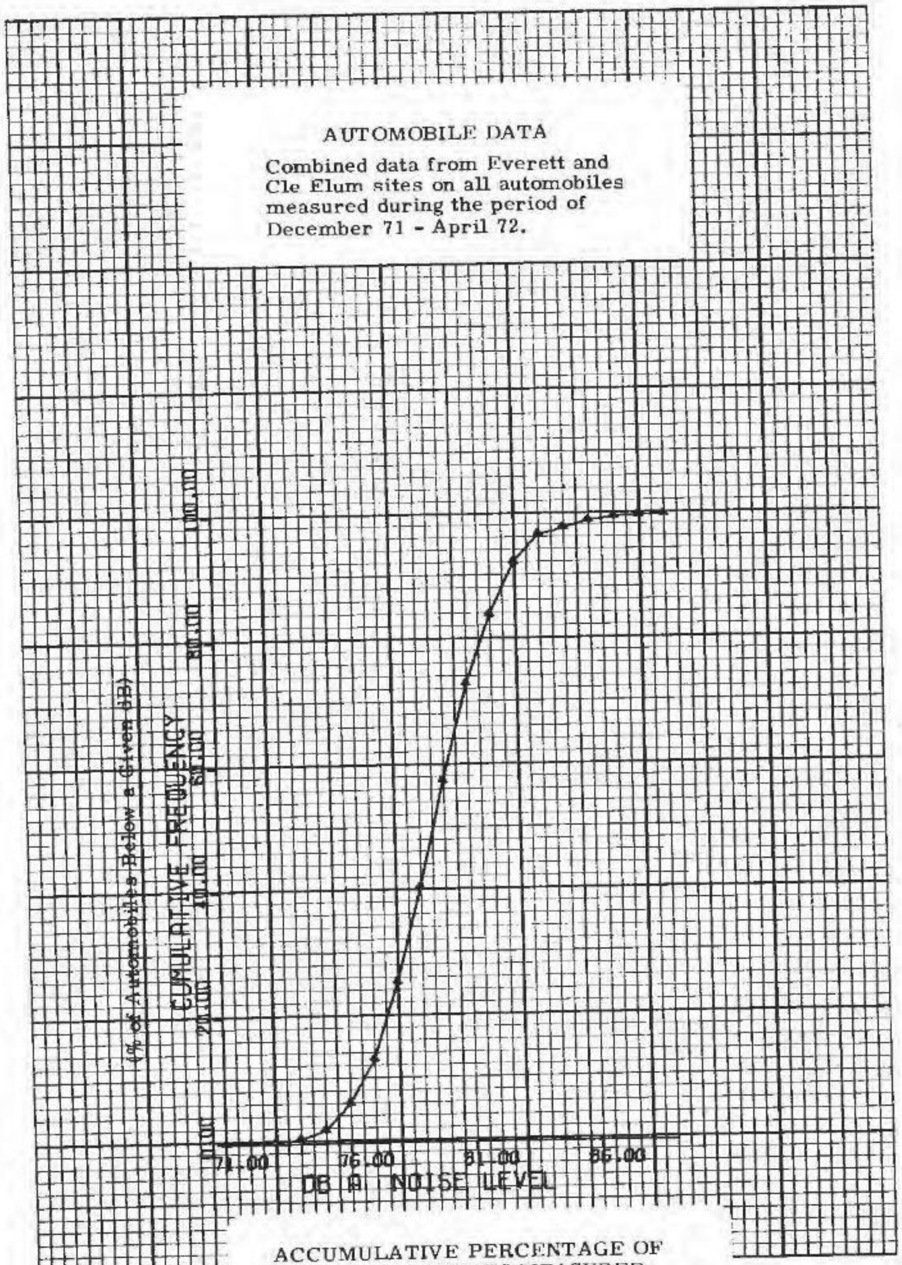
HISTOGRAM OF ALL AUTOMOBILES MEASURED

SAMPLE SIZE: 878

FIGURE 46.

57

Auguscik-25
(Cont.)



ACCUMULATIVE PERCENTAGE OF
ALL AUTOMOBILES MEASURED

SAMPLE SIZE: 878

FIGURE 47.

58

Auguscik-25
(Cont.)

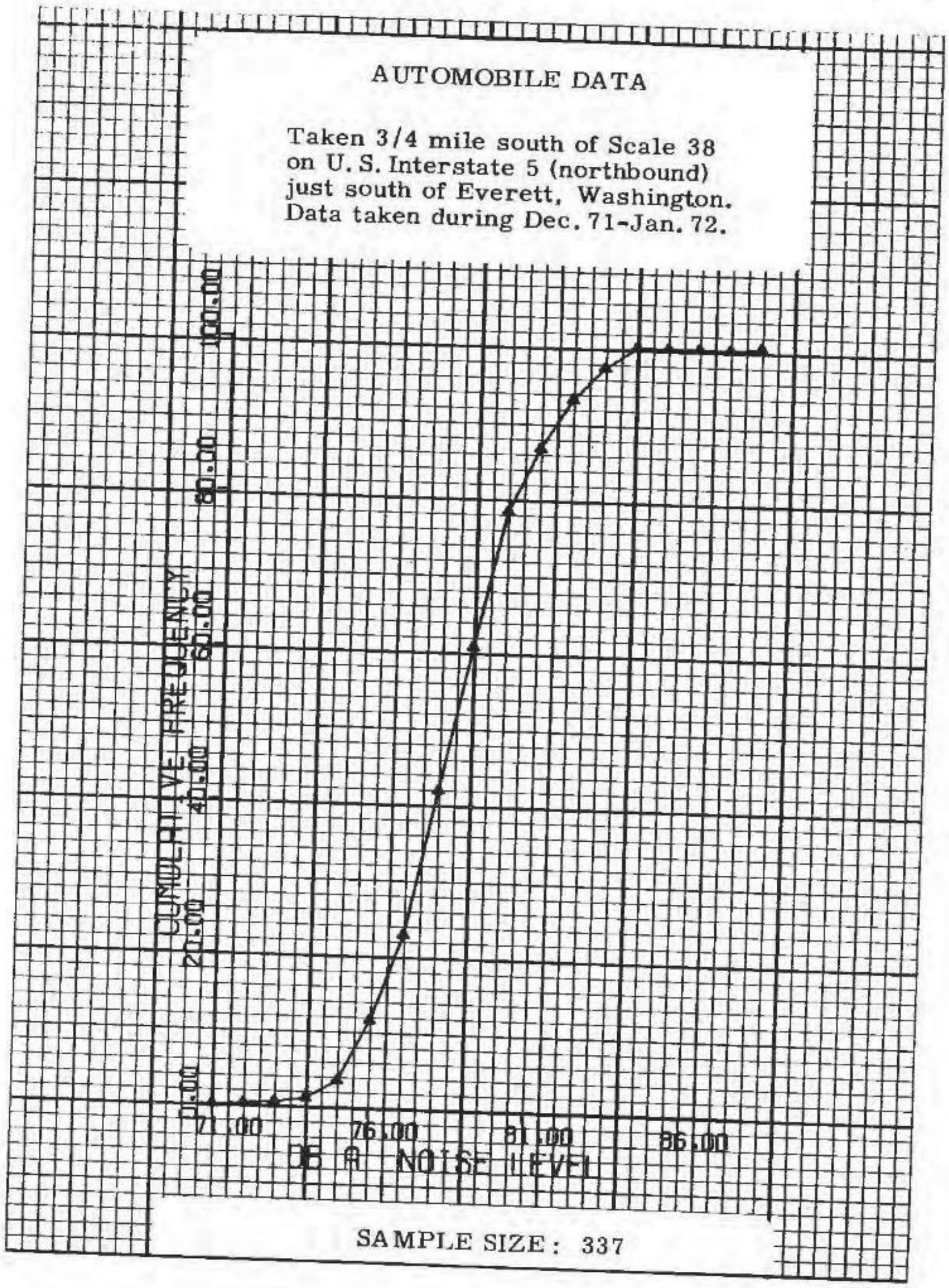


FIGURE 48.

59

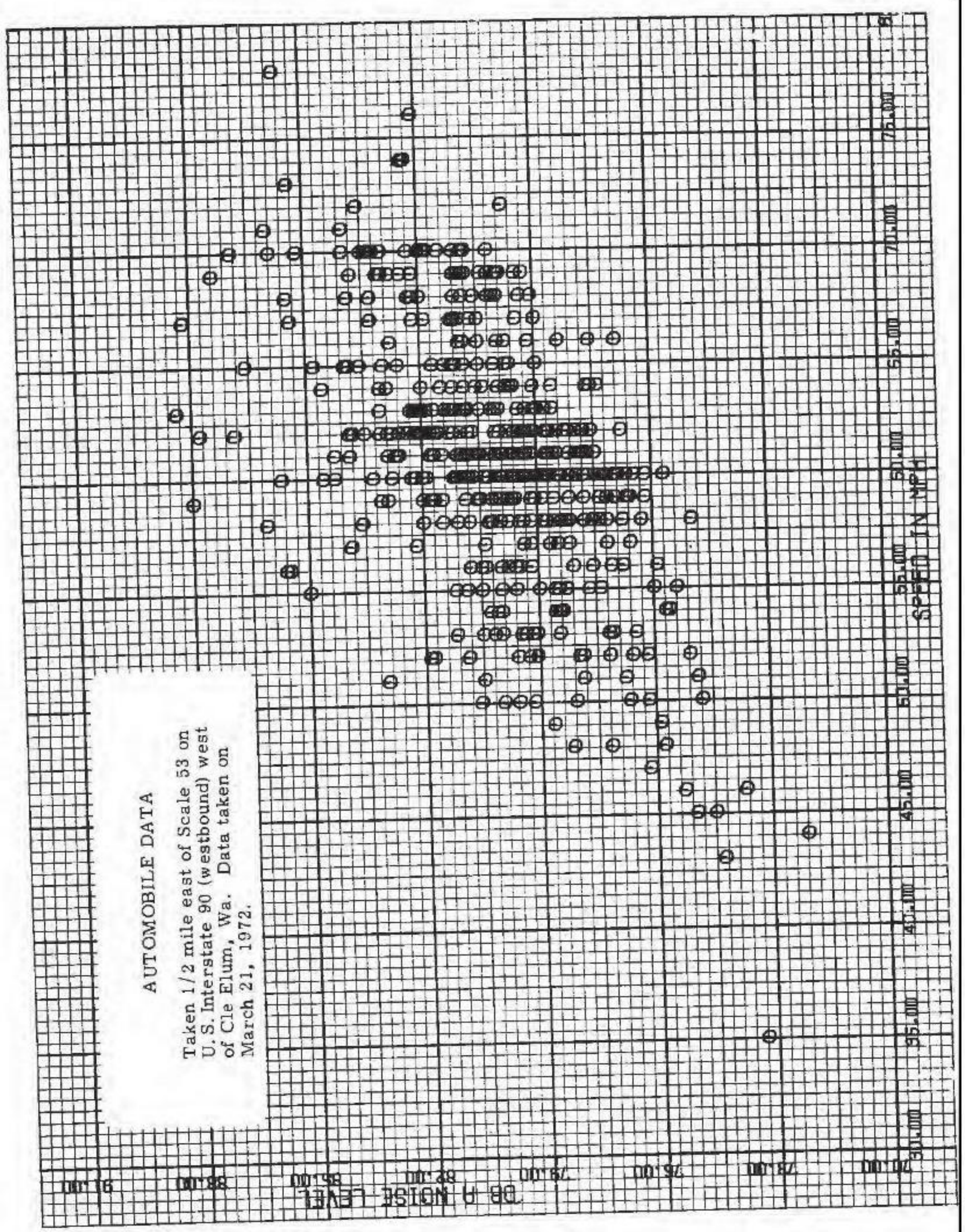

AUTOMOBILE DATA
Taken 1/2 mile east of Scale 53 on U.S. Interstate 90 (westbound) west of Cle Elum, Wa. Data taken on March 21, 1972.
SPEED IN MPH
DB A NOISE LEVEL

FIGURE 49.

60

Auguscik-25
(Cont.)

TYPICAL PHOTOGRAPHS

Figure 50 is a photograph of one of the quiet trucks; its noise level was 85.1 dBA when traveling at 52 mph. The H in the license number indicates it is a diesel truck; its measured weight was 31,000 lb; and it is a Mack truck. This photograph was taken at Cle Elum and gives an example of one of the quieter trucks traveling at more or less full-speed and weighing over 30,000 lb.

Figure 51, also taken at Cle Elum, is a gasoline-powered truck manufactured by Chevrolet and weighing 11,000 lb. It was extremely quiet (77 dBA) even though it was going 50 mph. Figure 52 is another fairly quiet truck (83 dBA), going 50 mph. It weighed 34,000 lb, was gasoline-powered, and was manufactured by GMC. Apparently, GMC gasoline-powered trucks tend to be quiet although their diesel trucks are noisier. Its B-scale measurement was 87, which indicates the truck probably could have been even quieter with better muffling.

Figure 53 shows an example of a truck at the other end of the scale. This is a diesel truck going 51 mph, weighing 22,000 lb. It is on the noisy side at 93.7 dBA. The dBB reading is virtually the same--this means that it is putting out comparatively little low-frequency sound. It may be relatively well-muffled, but other sounds are overriding the exhaust to make this a rather noisy vehicle.

Figures 54 through 61 show a total of 72 different trucks, together with their noise data, speed, weight, and license number. Looking through these pictures will help give an idea of what some of the quiet, noisy, and mid-range trucks look like. As can be seen, the external appearance of a truck does not give a positive indication of the noise it radiates as it moves along the State's highways.

Auguscik-25 (Cont.)

Fig. 50. 3:41 p.m. 52 mph — Ga. # HI667 — (Cle Elum) 85.1 dBA 31,000 lb

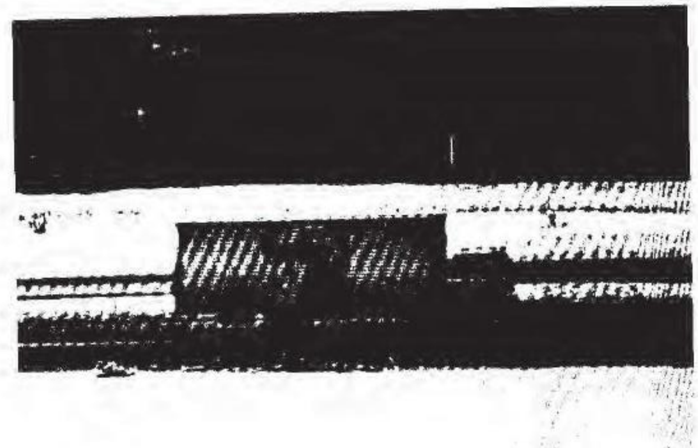


Fig. 51. 3:45 p.m. 54 mph — # T76835 — (Cle Elum) 77 dBA 11,000 lb

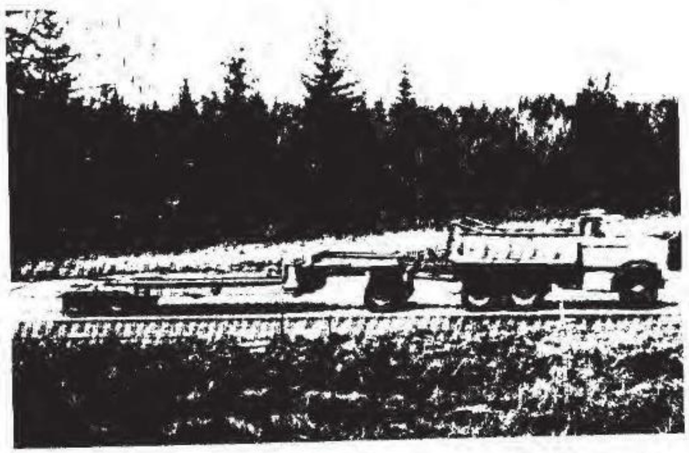


Fig. 52. 10:09 a.m. 50 mph — # A68613 — (Everett) 83.8 dBA 34,000 lb

Fig. 53. 12:47 p.m. 51 mph — # H11093 — (Everett) 93.7 dBA 22,000 lb

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Auguscik-25
(Cont.)

FIGURE 54.

63

Auguscik-25
(Cont.)

FIGURE 55.

64

Auguscik-25
(Cont.)

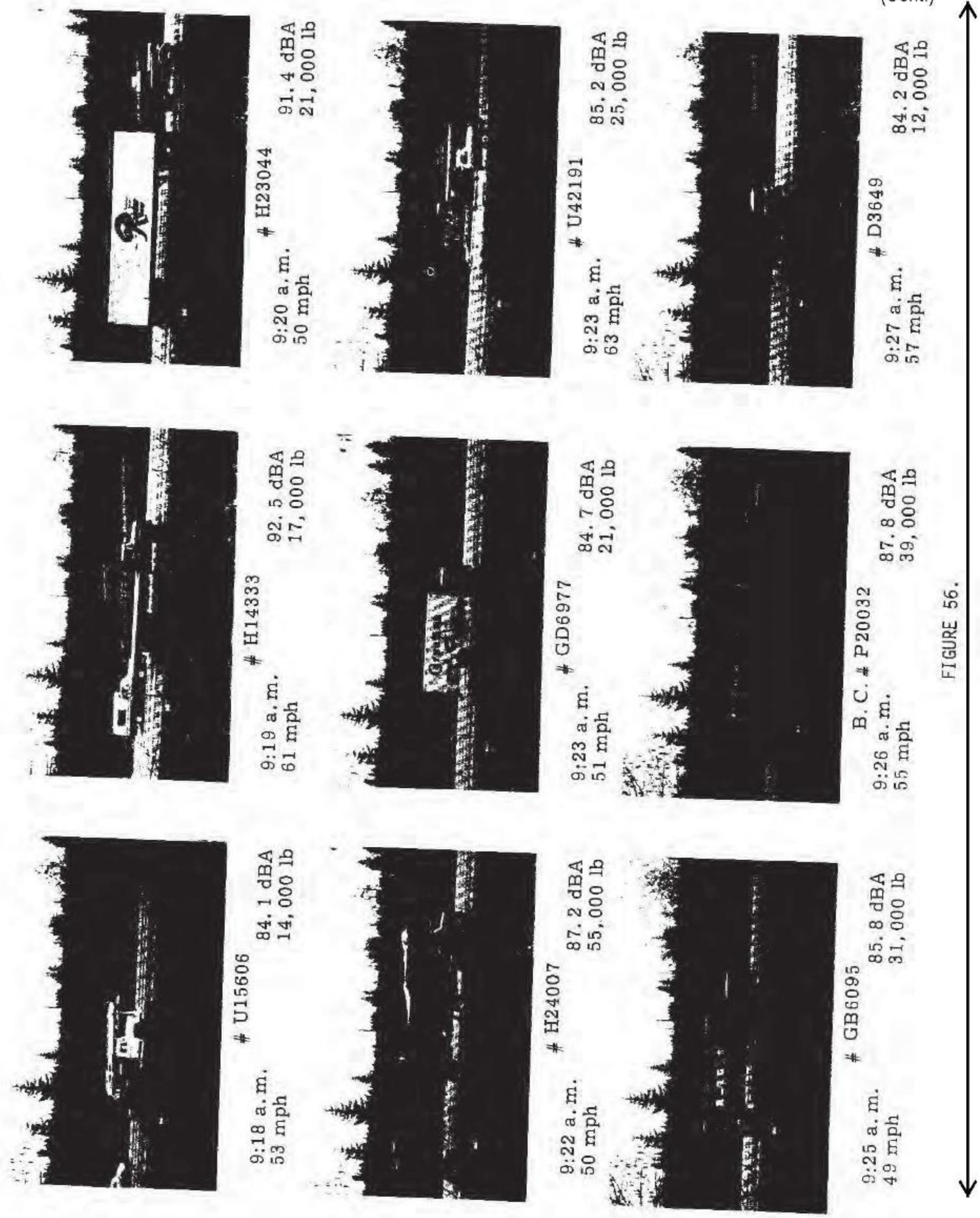


FIGURE 56.

65

Auguscik-25
(Cont.)

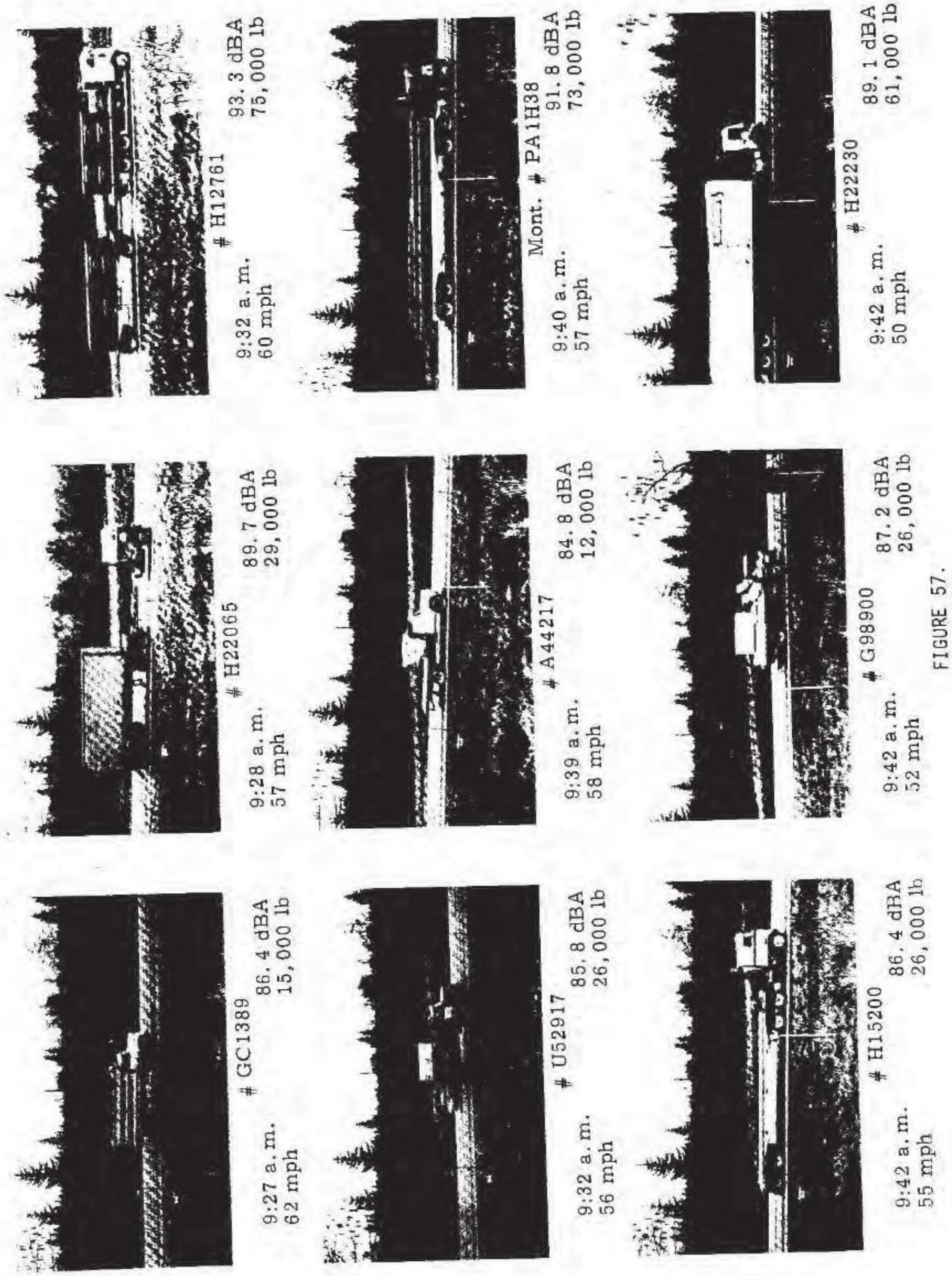


FIGURE 57.

66

Auguscik-25
(Cont.)

FIGURE 58.

67

Auguscik-25
(Cont.)

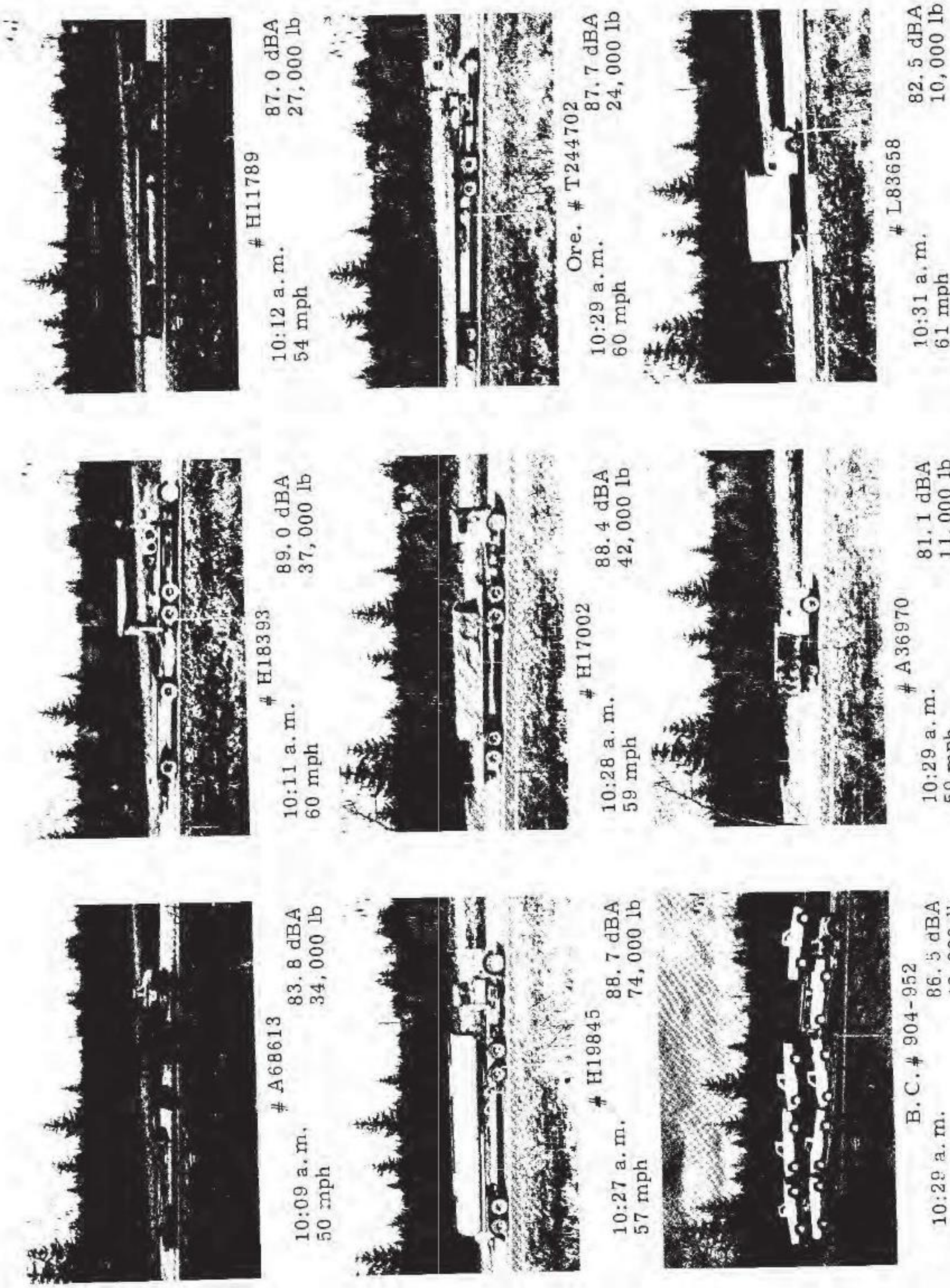


FIGURE 59.

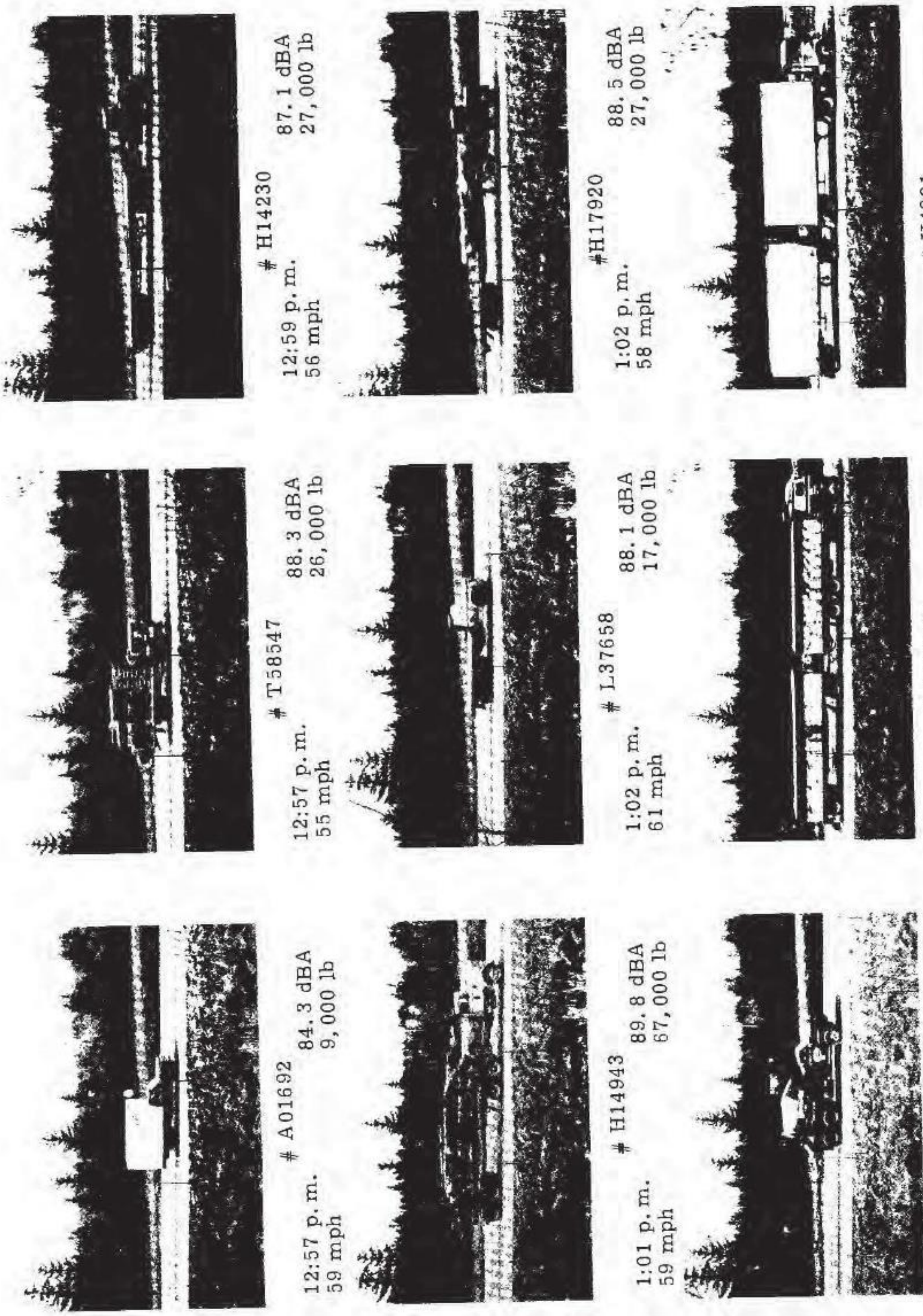
68

Auguscik-25
(Cont.)

FIGURE 60.

69

Auguscik-25
(Cont.)



12:57 p.m. 59 mph # A01692 84.3 dBA 9,000 lb

12:57 p.m. 55 mph # T58547 88.3 dBA 26,000 lb

12:59 p.m. 56 mph # H14230 87.1 dBA 27,000 lb

1:01 p.m. 59 mph # H14943 89.8 dBA 67,000 lb

1:02 p.m. 61 mph # L37658 88.1 dBA 17,000 lb

1:02 p.m. 58 mph #H17920 88.5 dBA 27,000 lb

1:03 p.m. 51 mph # H16596 86.3 dBA 23,000 lb

1:04 p.m. 61 mph # H17676 90.1 dBA 76,000 lb

1:05 p.m. 51 mph # H4981 87.0 dBA 28,000 lb

FIGURE 61.

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CURRENT LEGISLATION

Forty-eight states and six Canadian provinces were queried about their legislation on highway vehicle noise. As of December 1971, 15 states and 3 provinces had no motor vehicle regulation whatsoever, while 10 states and 2 provinces had minimal noise regulation which prohibits the emission of excessive or unusual noise and requires a muffler. The legislatures in two states and two provinces have authorized the establishment of noise levels for motor vehicles although no noise levels have yet been established. Specific decibel levels for the noise emitted by motor vehicles have been set by six states as follows:

State	Trucks with speed over 35 mph	Cars with speed over 35 mph
California*	90 dBA at 50 ft	82 dBA at 50 ft
Idaho	92 dBA at 20 ft (for any vehicle)	
Minnesota	90 dBA at 50 ft	86 dBA at 50 ft
Nevada	90 dBA at 50 ft	82 dBA at 50 ft (patterned after Calif.)
New York	88 dBA at 50 ft (for any vehicle moving less than 35 mph)	
Pennsylvania	92 dBA at 50 ft	86 dBA at 50 ft

Appendix F is a compilation of all the responses to our request for this information.

Auguscik-25 (Cont.)

*California sets the lowest noise levels thus far.

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MUFFLERS

As part of this survey, letters were sent to a large number of muffler manufacturers requesting information from them on their mufflers, particularly those expected to be used on trucks. The data requested included (1) model numbers, (2) acoustic performance (how many dB and what frequencies, etc.), (3) effect on engine (back-pressure generated), (4) mechanical specifications such as weight and size, (5) life expectancy, and (6) cost.

The returns from the manufacturers were rather disappointing in that none of them would give cost information, some claiming there were no list prices, that all transactions were the result of negotiations; others would simply say that their costs were found reasonable by their customers.

In addition, few of the major muffler manufacturers gave any exact noise specifications for their mufflers. Nevertheless, it is anticipated that as more states enact noise legislation, these manufacturers will become more concerned with publishing the exact noise attenuation capabilities of their line of mufflers. At the present time, Donaldson, Riker, Alexander-Tagg, and Stemco give some noise specifications for their mufflers along with having a line of mufflers which "satisfy" California's 88 dBA noise limit. Donaldson gives the most detailed and comprehensive noise reduction and back-pressure specifications for their mufflers. AMF Beaird also gives extensive specifications; however, they are mainly concerned with stationary and marine-based applications.

Auguscik-25 (Cont.)

There are five main considerations in muffler design: (1) physical design or mechanical specifications, such as size and weight, (2) noise attenuation, (3) engine back-pressure, (4) muffler life, and (5) cost. The final performance of a muffler is a trade-off of the above five factors.

In general, if very good acoustic performance together with very low back-pressure is desired, the cost, weight, and size of the muffler will go up. Or, lower cost for the same acoustic performance could be attained if a higher back-pressure could be tolerated. There are no technical mysteries here. A muffler could be built to conform to almost any desired noise level if enough cost, space, and weight were allowed. The information from the manufacturers, however, is too sketchy at present to provide any curves of cost versus performance for this report.

It should be emphasized that the exhaust is only one source of noise. The engine radiates noise directly as does the piping between the engine and the muffler (if it is not sufficiently rigid and heavy). In addition, there is tire noise, etc. It is not economically justified to reduce the exhaust noise more than perhaps 6 dB below the overall truck noise level.

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Finally, a belief shared by many of the muffler manufacturers was that exhaust noise could be considerably reduced by educating the driver to the fact that an increase in exhaust noise does not necessarily result in an increase in horsepower or a decrease in back-pressure.

Appendix G is a compilation of the muffler manufacturers' response to our request for data.

Auguscik-25 (Cont.)

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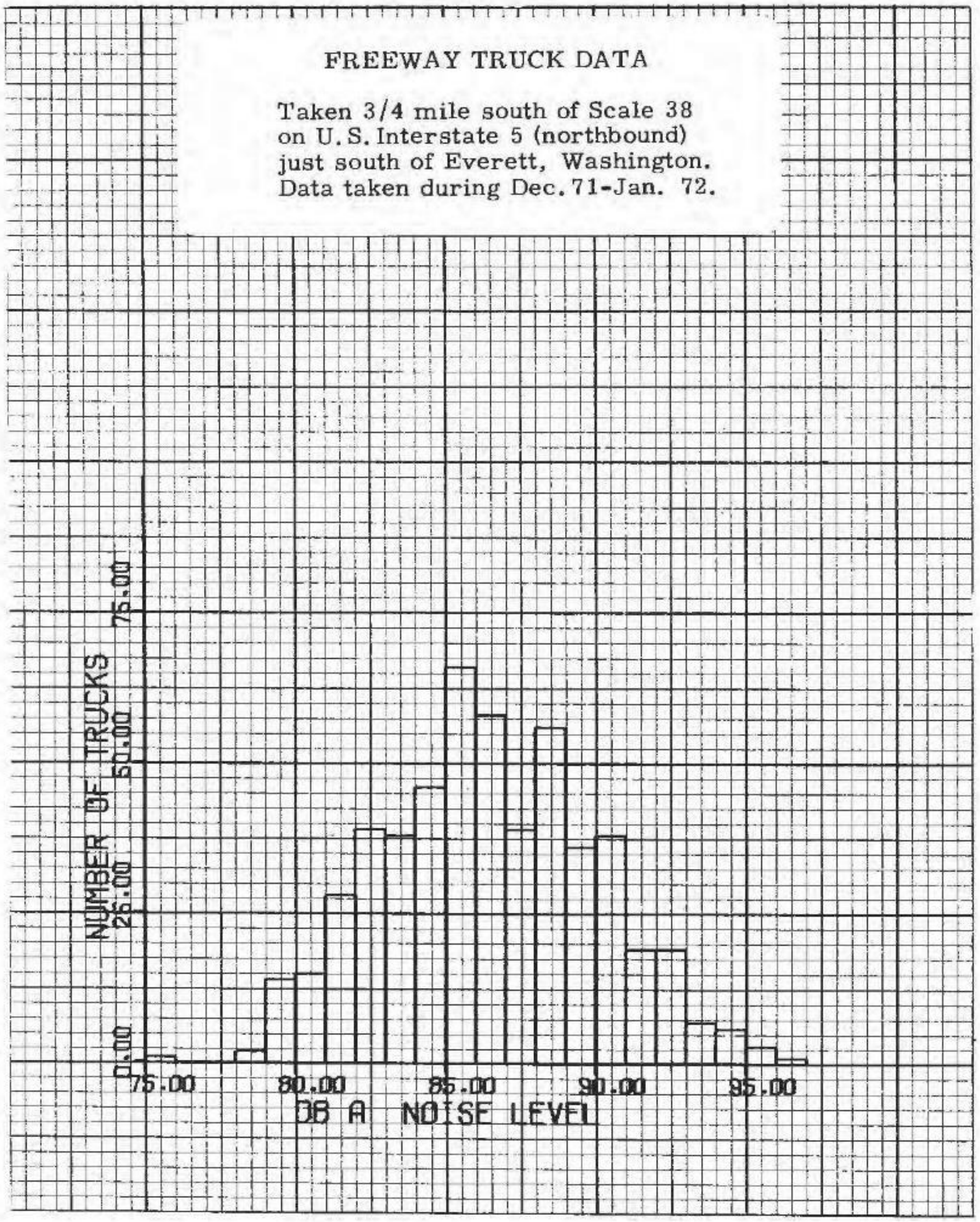
Auguscik-25
(Cont.)

APPENDIX A

DATA TAKEN DURING DECEMBER 1971 - JANUARY 1972, 3/4 MILE SOUTH OF SCALE 38 ON U.S. INTERSTATE 5 (NORTHBOUND) JUST SOUTH OF EVERETT, WASHINGTON.

(See Figure 17 in main text for key to symbols representing each class of truck.)

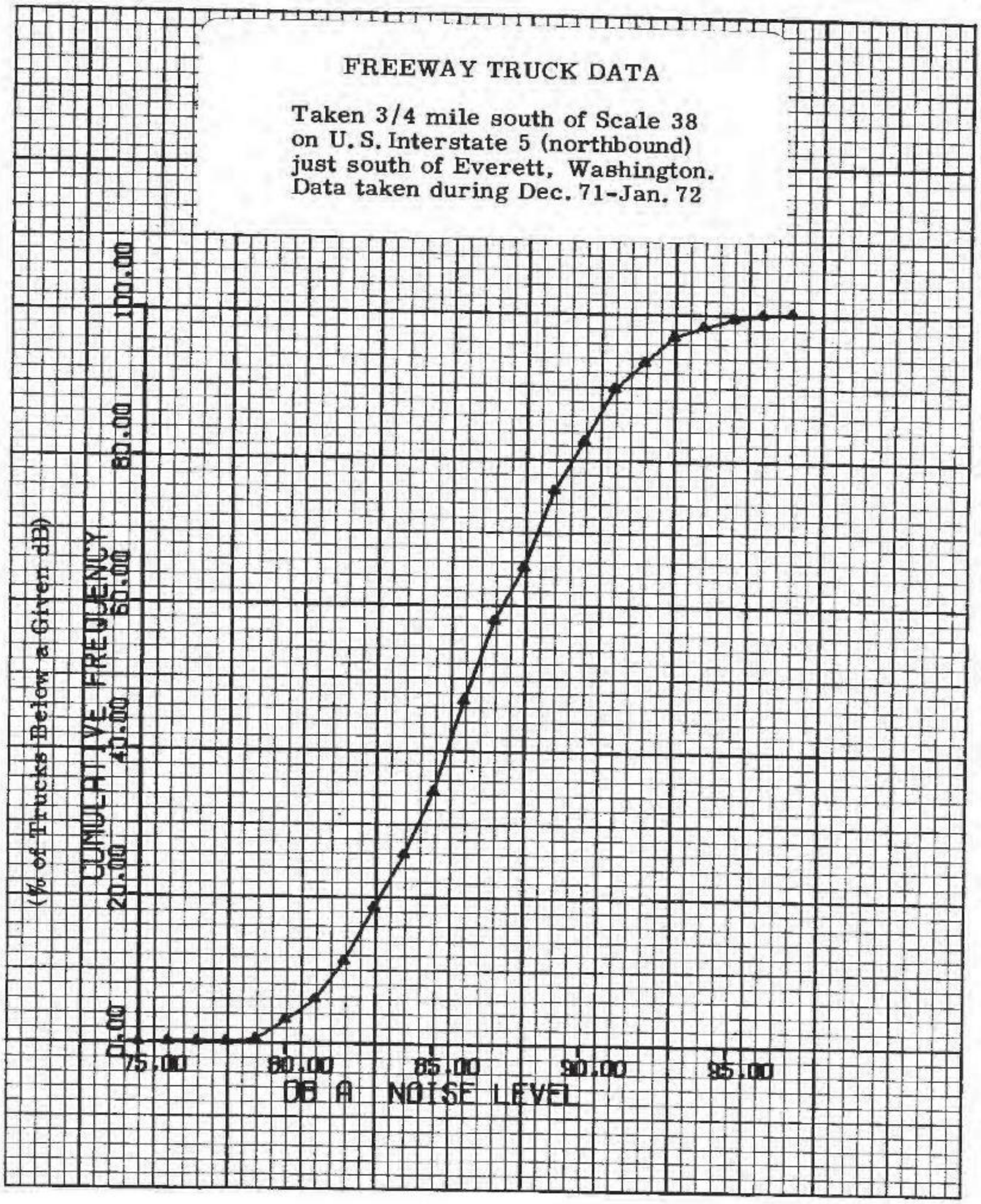


HISTOGRAM OF ALL TRUCKS MEASURED

SAMPLE SIZE: 531

A1

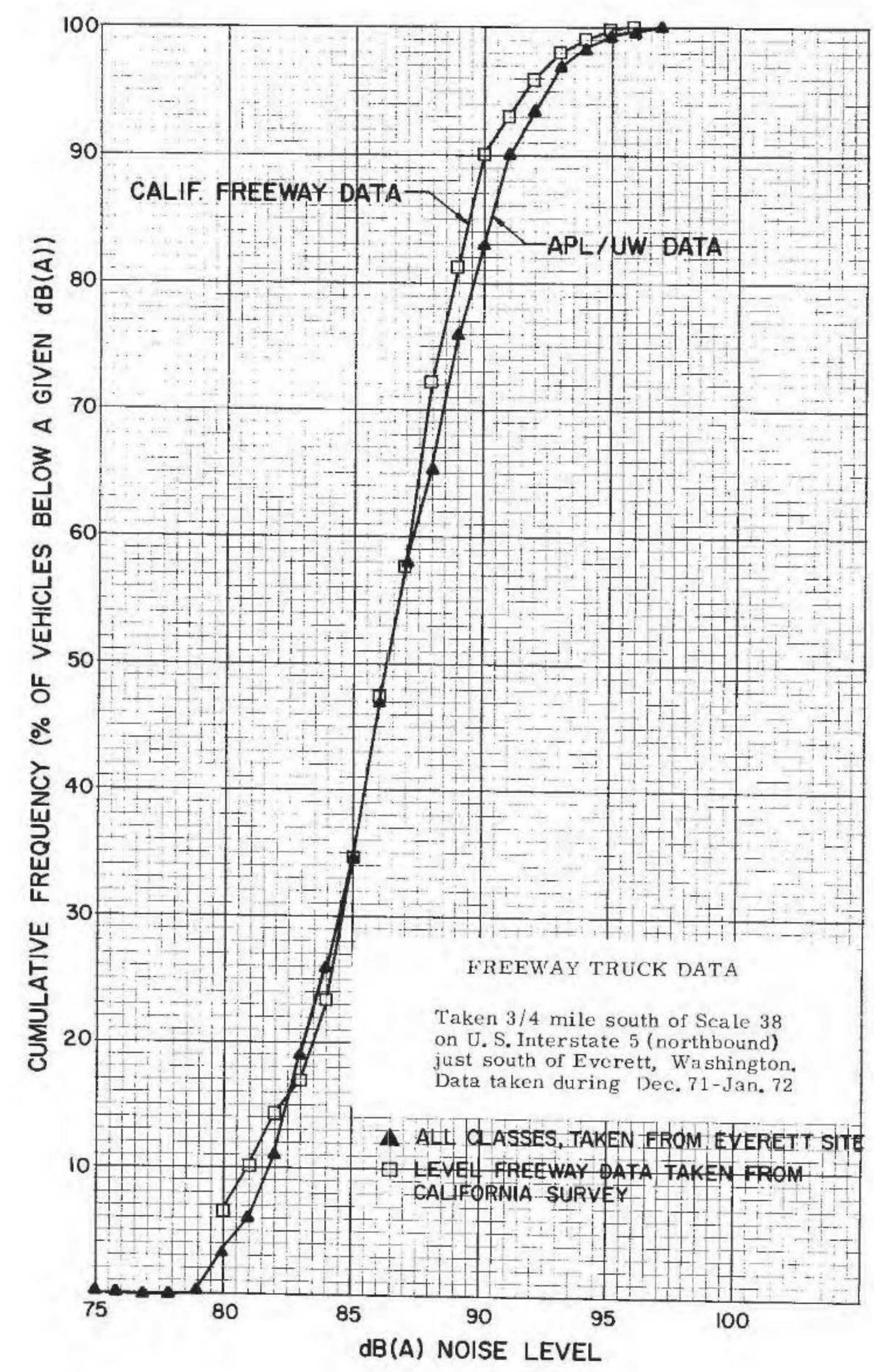
Auguscik-25
(Cont.)



ACCUMULATIVE PERCENTAGE
OF ALL TRUCKS MEASURED

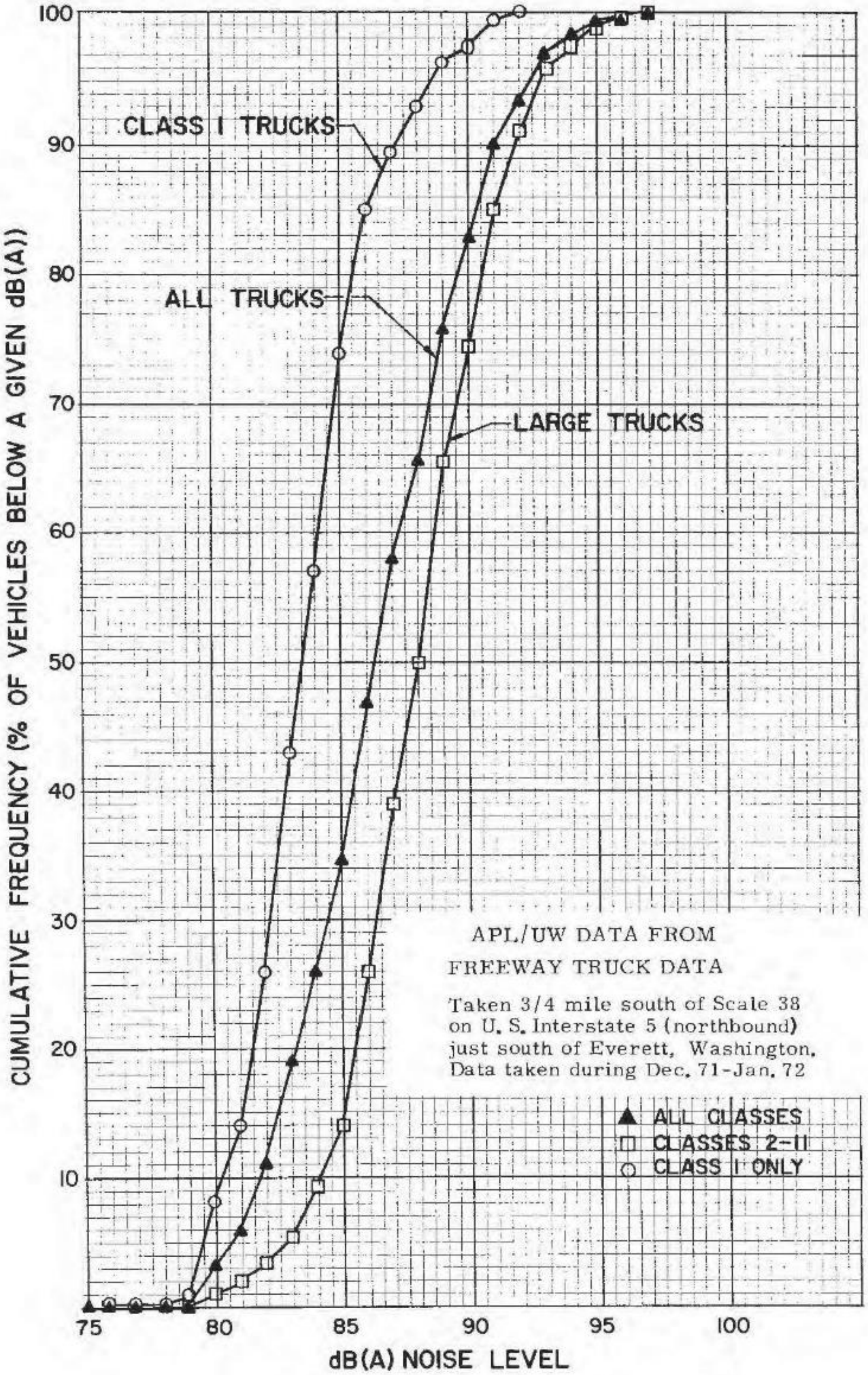
SAMPLE SIZE: 531

A2



Auguscik-25
(Cont.)

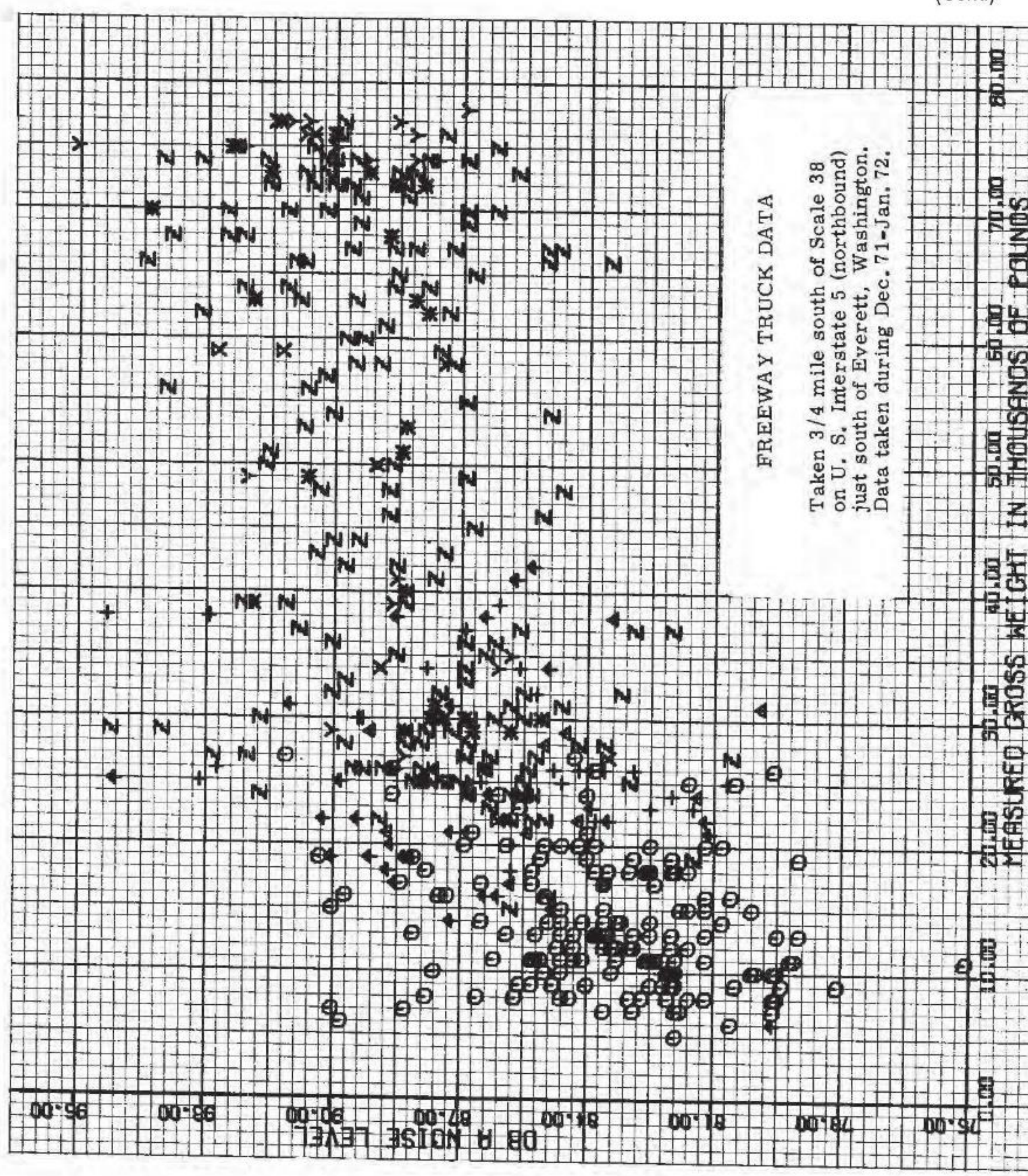
A3



Auguscik-25 (Cont.)

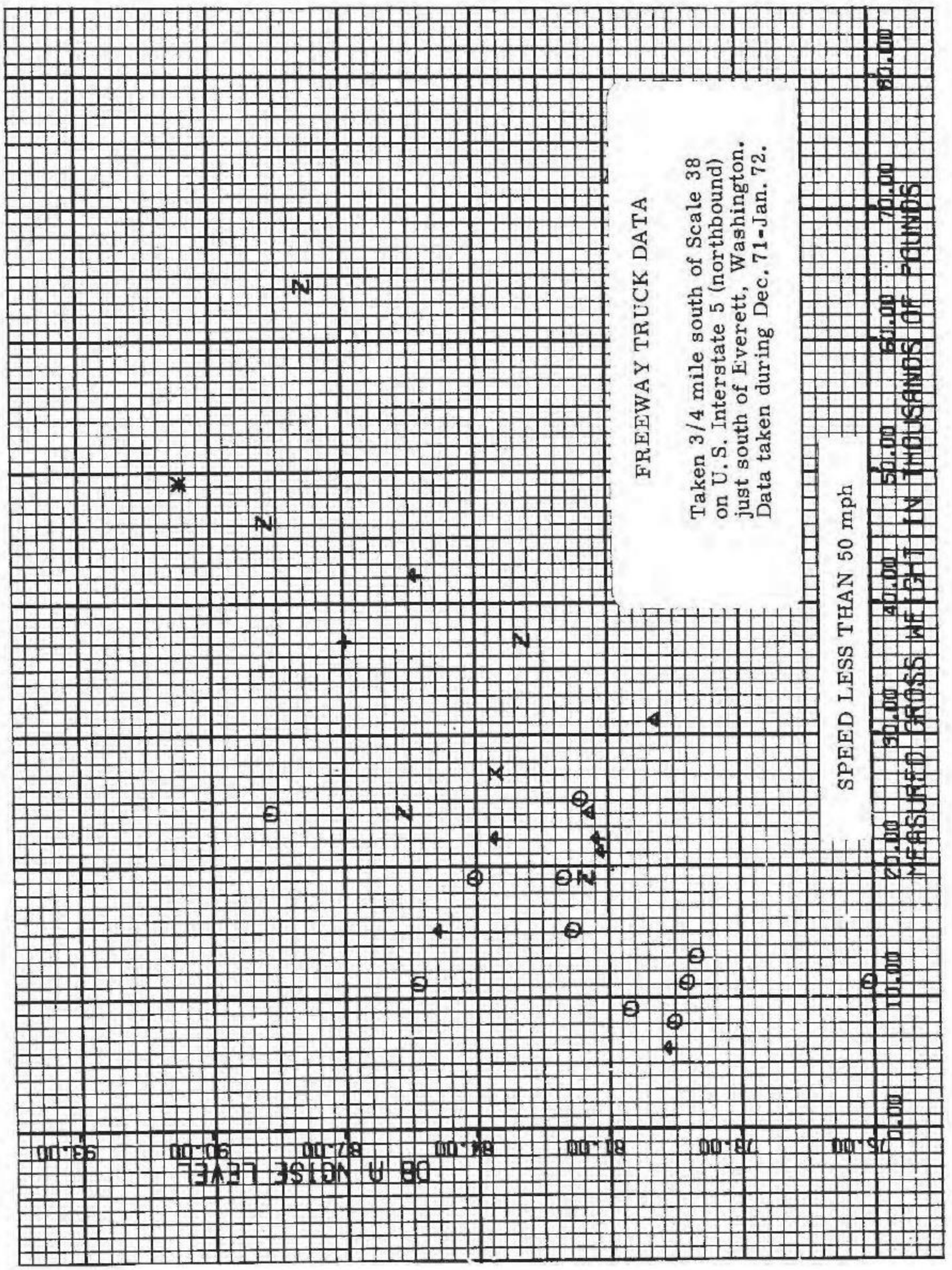
A4

Auguscik-25
(Cont.)



A5

Auguscik-25
(Cont.)



A6