Technical Development Document for the Final Effluent Limitations Guidelines and Standards for the Meat and Poultry Products Point Source Category (40 CFR 432)

The full document is available at: http://www.epa.gov/ost/guide/mpp/

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APPENDIX A

ANALYTICAL METHODS AND BASELINE VALUES

The analytical methods described in this appendix were used to determine pollutant levels in wastewater samples collected by EPA and industry at a number of meat and poultry product facilities. (Sampling efforts are described in Section 3.) In developing the final rule, EPA used data from samples collected by EPA and industry to determine the levels of *Aeromonas*, ammonia as nitrogen, biochemical oxygen demand (BOD), carbonaceous biochemical oxygen demand, chemical oxygen demand (COD), chloride, *Cryptosporidium*, dissolved biochemical oxygen demand, dissolved total phosphorus, *Escherichia coli* (*E. coli*), fecal coliform bacteria, fecal *Streptococcus*, 21 metals, oil and grease (measured as *n*-hexane-extractable material [HEM]), nitrate/nitrite, six pesticides, *Salmonella*, total coliform bacteria, total dissolved solids (TDS), total Kjeldahl nitrogen (TKN), total organic carbon (TOC), total orthophosphate, total phosphorus, total residual chlorine, total suspended solids (TSS), and volatile residue. As explained in Section 7, EPA is regulating a subset of these pollutants.

Sections A.1 and A.2 of this appendix explain nominal quantitation limits and baseline values. Section A.3 describes the reporting conventions used by laboratories in expressing the results of the analyses. Section A.4 describes each analytical method and the corresponding baseline values that EPA used in determining the pollutants of concern. Section A.5 defines total nitrogen. Table A-1 lists the analytical methods and baseline values used for each pollutant.

A.1 NOMINAL QUANTITATION LIMITS

The nominal quantitation limit is the smallest quantity of an analyte that can be reliably measured with a particular method. Protocols used for determining nominal quantitation limits in a particular method depend on the definitions and conventions that EPA used at the time the method was developed. The nominal quantitation limits associated with the methods addressed in this section fall into five categories:

1. The first category pertains to EPA Methods 1660 and 1664, which define the minimum level (ML) as the lowest level at which the entire analytical system must give a recognizable signal and an acceptable calibration point for the analyte. These methods are described in Section A.4.1.

2. The second category pertains specifically to EPA Method 1620, which is explained in detail in Section A.4.2.

3. The third category pertains to the remainder of the chemical methods (classical wet chemistry and pesticides) in which a variety of terms are used to describe the lowest level at which measurement results are quantitated. In some cases (especially with the classical wet chemistry analytes) the methods date to the 1970s and 1980s when EPA used different concepts of quantitation. These methods typically list a measurement range or lower limit of measurement. The terms differ by method and, as discussed in subsequent sections, the levels presented are not always representative of the lowest levels laboratories currently can achieve.

   For methods associated with a calibration procedure, the laboratories demonstrated through a low-point calibration standard that they were capable of reliable quantitation at method-specified (or lower) levels. In such cases these nominal quantitation limits are operationally equivalent to the ML (though not specifically identified as such in the methods). In the case of titrimetric or gravimetric methods, the laboratory adhered to the established lower limit of the measurement range published in the methods. Details of the specific methods are presented in Sections A.4.3 through A.4.17.

4. The fourth category pertains to *Cryptosporidium*. There is currently no detection limit associated with the method used to determine *Cryptosporidium* (EPA Method 1622, described in Section A.4.18), so when *Cryptosporidium* was not found in the sample, no number was associated with the sample. Therefore, there is no nominal quantitation limit for *Cryptosporidium*.

5. The fifth category pertains to all microbiological methods except methods for *Cryptosporidium*. The fifth category pertains specifically to the multiple-tube test procedure, explained in detail in Section A.4.19.

A.2 BASELINE VALUES

As described further in Section 7, in determining the pollutants of concern, EPA compared the reported concentrations for each pollutant to a multiple of the baseline value. As described in Section A.3 and shown in Table A-1, for most pollutants, the baseline value was set equal to the nominal quantitation limit for the analytical method. EPA made two general types of exceptions, and these are briefly described below. Section A.4 provides additional details about these exceptions in the context of the analytical method.

The first type of exception occurred when baseline values differed from the nominal quantitation limits in the analytical methods. When the baseline values had lower values, EPA made these exceptions because the laboratory had submitted data that demonstrated reliable measurements could be obtained at lower levels for those pollutants. When the baseline values had higher values, EPA concluded that the nominal quantitation limit for a specified method was less than the level that laboratories could reliably achieve and adjusted the baseline value upward.

The second type of exception was setting baseline values at a common value for multiple analytical methods for the same pollutant. For some analytes, EPA permitted the laboratories to choose between methods to accommodate sample characteristics. When these methods had different nominal quantitation limits, EPA usually used the one with the lowest value or the one associated with the method used for most samples.

A.3 ANALYTICAL RESULTS REPORTING CONVENTIONS

All of the analytical chemistry data were reported as liquid concentrations in weight/volume units, e.g., micrograms per liter (µg/L). *Cryptosporidium* results were reported in the calculated number of *Cryptosporidium* oocysts detected per liter. Bacteriological data generated using multiple-tube fermentation techniques were reported as most probable number per 100 milliliters (MPN/100 mL) or for data generated using membrane filtration techniques, as colony forming units (CFU/100 mL).

The laboratories expressed the results of the analyses either numerically or as not quantitated[1] for a pollutant in a sample. If the pollutant was quantitated[2] in the sample, then the result was expressed numerically. For the non-quantitated results, for each sample, the laboratories reported a "sample-specific quantitation limit."[3] The sample-specific quantitation limit for a particular pollutant is generally the smallest quantity in the calibration range that can be measured in any given sample. The sample-specific quantitation limit was used as a reporting limit for this industry. Two reporting examples are provided below.

Example 1: For a hypothetical pollutant X, the sample-specific quantitation limit is 10 µg/L. When the laboratory quantitated the amount of pollutant X in the sample as being 15 µg/L, the result would be reported as "15 µg/L".

Example 2: For the hypothetical pollutant X, the sample-specific quantitation limit is 10 µg/L. When the laboratory could not quantitate the amount of pollutant X in the sample, the result would be reported as "<10 µg/L." That is, the analytical result indicated a value less than the sample-specific quantitation limit of 10 µg/L. The actual amount of pollutant X in that sample is between zero (i.e., the pollutant is not present) and 10 µg/L. If a pollutant is reported as non-quantitated in a particular wastewater sample, this does not mean that the pollutant is not present in the wastewater. It means that analytical techniques (whether because of instrument limitations, pollutant interactions, or other reasons) do not permit its measurement at levels below the sample-specific quantitation limit.

In its calculations, EPA generally substituted the reported value of the sample-specific quantitation limit for each non-quantitated result. In a few cases described in Section A.4.1, when the sample-specific quantitation limit was less than the baseline value, EPA substituted the

[1] Elsewhere in this document and in the preamble to the final rule, EPA refers to pollutants as "not detected" or "non-detected." This appendix uses the term "not quantitated" or "non-quantitated" rather than non-detected.

[2] Elsewhere in this document and in the preamble to the final rule, EPA refers to pollutants as "detected." This appendix uses the term "quantitated" rather than detected.

[3] Elsewhere in this document and in the preamble to the proposed rule, EPA refers to a "sample-specific quantitation limit" as a "sample-specific detection limit" or, more simply, as a "detection limit."

baseline value for the non-quantitated result. And in a few instances (also described in Section A.4.1), when the quantitated value was below the baseline value, EPA considered these values to be non-quantitated in the statistical analyses and substituted the baseline value for the measured value.

A.4 ANALYTICAL METHODS

EPA and industry analyzed all of the meat product facility wastewater samples using methods identified in Table A-1. (As explained in Section 7, EPA is regulating only a subset of these analytes.) EPA generally used either EPA methods from *Methods for Chemical Analysis of Water and Wastes* (MCAWW) or the American Public Health Association's *Standard Methods for the Examination of Water and Wastewater* (SM). Table A-1 provides a summary of the pollutants analyzed, the method(s) used to measured each analyte, the nominal quantitation levels, and the baseline levels. The following sections provide additional information supporting the summary in Table A-1.

In analyzing samples, EPA generally used approved analytical methods listed in Title 40, Part 136 of the Code of Federal Regulations (40 CFR 136) for compliance monitoring or methods EPA has used for decades in support of effluent guidelines development. Exceptions for use of non-approved methods are explained in the method-specific subsections that follow Table A-1. Except for nitrate/nitrite, EPA established limitations or standards based only on data generated by approved methods listed in 40 CFR 136. As explained in Section A.4.10, EPA used nitrate/nitrite data from Method 300.0 to develop the final limitations and standards for total nitrogen and is promulgating the use of Method 300.0 for compliance.

Each of the following sections states whether the method is approved for compliance monitoring in 40 CFR 136 (even if the pollutant will not be regulated), provides a short description of the method, identifies the nominal quantitation limit, and explains EPA's choice for the baseline value. The sections are ordered alphabetically by analyte name within the five categories identified in Section A.1.

Table A-1. Analytical Methods and Baseline Values

Analyte	Method	CAS Number	Sample Collection & Analysis	Nominal Quantitation Value	Baseline Value
Aeromonas	9260L	C2101	EPA	2.0/100 mL	2.0/100 mL
Ammonia as nitrogen	350.1	7664417	Industry	0.01 mg/L	0.20 mg/L
	350.2		EPA	0.20 mg/L	
	350.3		Industry	0.03 mg/L	
	SM4500-NH3 B			N/A	
	SM4500-NH3 C			0.02 mg/L	
	SM4500-NH3 E			5.0 mg/L	
	SM4500-NH3 F			0.03 mg/L	
	SM4500-NH3 G			0.8 mg/L	
Antimony	1620	7440360	EPA	20.0 µg/L	20.0 µg/L
Arsenic	1620	7440382	EPA	10.0 µg/L	10.0 µg/L
Barium	1620	7440393	EPA	200.0 µg/L	200.0 µg/L
Beryllium	1620	7440417	EPA	5.0 µg/L	5.0 µg/L
BOD_5	405.1	C003	EPA	2.0 mg/L	2.0 mg/L
	SM5210 B			2.0 mg/L	
Boron	1620	7440428	EPA	100.0 µg/L	100.0 µg/L
Cadmium	1620	7440439	EPA	5.0 µg/L	5.0 µg/L
Carbonaceous BOD_5	405.1	C002	EPA	2.0 mg/L	2.0 mg/L
	SM5210 B			2.0 mg/L	
Carbaryl	632	63252	EPA	1.0 µg/L	1.0 µg/L
COD	410.1	C004	EPA	50.0 mg/L	5.0[a] mg/L
	410.2			5.0 mg/L	
	410.4 (automated)			3.0 mg/L	
	410.4 (manual)			20.0 mg/L[b]	
	SM5220 B			5.0 mg/L	
	SM5220 C		Industry	50.0 mg/L	
	HACH 8000			3.0 mg/L	
Chloride	300.0	16887006	EPA	0.05 mg/L	1.0 mg/L
	325.3			1.0 mg/L	
Chromium	1620	7440473	EPA	10.0 µg/L	10.0 µg/L
cis-Permethrin	1660	61949766	EPA	5.0 µg/L	5.0 µg/L
Cobalt	1620	7440484	EPA	50.0 µg/L	50.0 µg/L
Copper	1620	7440508	EPA	25.0 µg/L	25.0 µg/L
Cryptosporidium	1622	137259508	EPA	0 oocysts/L	0 oocysts/L
Dichlorvos	1657	62737	EPA	2.0 µg/L	2.0 µg/L
Dissolved BOD_5	405.1	C003D	EPA	2.0 mg/L	2.0 mg/L

Table A-1. Analytical Methods and Baseline Values (Continued)

Analyte	Method	CAS Number	Sample Collection & Analysis	Nominal Quantitation Value	Baseline Value
Dissolved total phosphorus	365.2	14265442D	EPA	0.01 mg/L	0.01 mg/L
	365.3				
E. coli	SM9221 F	C050	EPA	2.0/100 mL	2.0/100 mL
Fecal coliform	SM9221 C	C2106	Industry	2.0/100 mL	2.0/100 mL
	SM9221 E		EPA	2.0/100 mL	
	SM 9222 D		Industry	2.0/100 mL	
Fecal Streptococcus	SM9230 B	C2107	EPA	2.0/100 mL	2.0/100 mL
HEM	1664	C036	EPA	5.0 mg/L	5.0 mg/L
	1664 A			5.0 mg/L	
Lead	1620	7439921	EPA	50.0 µg/L	50.0 µg/L
Malathion	1657	121755	EPA	2.0 µg/L	2.0 µg/L
Manganese	1620	7439965	EPA	15 µg/L	15 µg/L
Mercury	1620	7439976	EPA	0.20 µg/L	0.20 µg/L
Molybdenum	1620	7439987	EPA	10.0 µg/L	10.0 µg/L
Nickel	1620	7440020	EPA	40.0 µg/L	40.0 µg/L
Nitrate/Nitrite	300.0	C005	EPA	0.01 mg/L	0.05 mg/L
	352.1		Industry	0.1 mg/L	
	353.1		EPA	0.01 mg/L	
	353.2		EPA	0.05 mg/L	
	354.1		Industry	0.01 mg/L	
	SM4500-NO2 B		Industry	0.005 mg/L	
	SM4500-NO3 D		Industry	0.14 mg/L	
	SM4500-NO3 E		Industry	0.01 mg/L	
Oil and grease	413.1	C036	Industry	5.0 mg/L	5.0 mg/L
	SM5520 B		Industry	10.0 mg/L	
	SM 5520 D		Industry	10.0 mg/L	
Salmonella	FDA-BAM	68583357	EPA	2.0 mg/L	2.0 mg/L
Selenium	1620	7782492	EPA	5.0 µg/L	5.0 µg/L
Silver	1620	7440224	EPA	10.0 µg/L	10.0 µg/L
Tetrachlorvinphos	1657	22248799	EPA	2.0 µg/L	2.0 µg/L
Thallium	1620	7440280	EPA	10.0 µg/L	10.0 µg/L
Tin	1620	7440315	EPA	30.0 µg/L	30.0 µg/L
Titanium	1620	7440326	EPA	5.0 µg/L	5.0 µg/L
Total coliform	SM9221 B	E10606	EPA	2.0/100 mL	2.0/100 mL
Total dissolved solids	160.1	C010	EPA	10.0 mg/L	10.0 mg/L

Table A-1. Analytical Methods and Baseline Values (Continued)

Analyte	Method	CAS Number	Sample Collection & Analysis	Nominal Quantitation Value	Baseline Value
Total Kjeldahl nitrogen	351.2	C021	EPA	0.10 mg/L	0.5 mg/L
	351.3		EPA	0.50 mg/L	
	SM4500-Norg B		Industry	N/A	
	SM4500-NH3 E		Industry	5.0 mg/L	
Total organic carbon	415.1	C012	EPA	1.0 mg/L	1.0 mg/L
Total orthophosphate	300.0	C034	EPA	0.20 mg/L	0.01 mg/L
	365.2			0.01 mg/L	
Total phosphorus	365.2	14265442	EPA	0.01 mg/L	0.01 mg/L
	365.3		EPA	0.01 mg/L	
	365.4		Industry	0.01 mg/L	
	SM4500-P B		Industry	0.01 mg/L	
	SM4500-P E		Industry	0.01 mg/L	
	HACH 8190		Industry	0.01 mg/L	
Total residual chlorine	330.5	7782505	EPA	0.20 mg/L	0.20 mg/L
	HACH 8167			0.10 mg/L	
Total suspended solids	160.2	C009	EPA	4.0 mg/L	4.0 mg/L
	SM2540 D		Industry	4.0 mg/L	
trans-Permethrin	1660	61949777	EPA	5.0 µg/L	5.0 µg/L
Vanadium	1620	7440622	EPA	50.0 µg/L	50.0 µg/L
Volatile residue	160.4	C030	EPA	10.0 mg/L	10.0 mg/L
Yttrium	1620	7440655	EPA	5.0 µg/L	5.0 µg/L
Zinc	1620	7440666	EPA	20.0 µg/L	20.0 µg/L

[a] The baseline value was adjusted to reflect the lowest nominal quantitation limit of the titrimetric procedures (410.1, 410.2, and 5220B). See Section A.4.6 for a detailed explanation.

[b] Method 410.4 lists two different quantitation limits that are dependent on whether the automated or manual protocols were followed. The automated method limit is 3 mg/L and the manual method limit is 20 mg/L.

A.4.1 EPA Methods 1660 (*cis*-Permethrin, *trans*-Permethrin) and 1664, 1664A, 413.1, SM5520B, and SM5520D (HEM)

Laboratories used EPA Method 1660 to measure *cis*-permethrin and *trans*-permethrin, and EPA Methods 1664 and 1664A to measure *n*-hexane-extractable material (HEM). While 40 CFR 136 lists Method 1664A as an approved method for compliance monitoring of HEM, Part 136 does not list any methods for the pesticides *cis*-permethrin and *trans*-permethrin. Table 7 in 40 CFR 455, however, lists Method 1660 as approved for compliance monitoring of permethrin for the Pesticide Chemicals Point Source Category. (Permethrin is the common name given to any mixture of the two isomers, *cis*-permethrin and *trans*-permethrin.)

These methods use the minimum level (ML) concept for quantitation of the pollutant(s). The ML is defined as the lowest level at which the entire analytical system must give a recognizable signal and an acceptable calibration point for the analyte. When an ML is published in a method, EPA has demonstrated that the ML can be achieved in at least one well-operated laboratory. When that laboratory or another laboratory uses that method, the laboratory is required to demonstrate, through calibration of the instrument or analytical system, that it can achieve pollutant measurements at the ML.

For *cis*-permethrin, *trans*-permethrin, and HEM, EPA used the method-specified MLs as the baseline values. In determining the pollutants of concern and in calculating the HEM standards, if a quantitated value or sample-specific quantitation limit was reported with a value less than the ML specified in the method, EPA substituted the value of the ML and assumed that the measurement was not quantitated. For example, for *cis*-permethrin with an ML of 5 µg/L, if the laboratory reported a quantitated value of 3 µg/L, EPA would have assumed that the concentration was not quantitated[4] with a sample-specific quantitation limit of 5 µg/L. The objective of this comparison was to identify any results for the three pollutants reported below the method-defined ML. Results reported below the ML were changed to the ML to ensure that all results used by EPA were reliable. In most cases, the quantitated values and sample-specific quantitation limits were equal to or greater than the baseline values.

[4] As explained in Appendix C, EPA applied different statistical assumptions to quantitated and non-quantitated results.

A.4.2 EPA Method 1620 (Metals)

Laboratories used EPA Method 1620 to measure the concentrations of 21 metals. Although EPA Method 1620 is not listed in 40 CFR 136 as an approved method for compliance monitoring, it represents a consolidation of the analytical techniques in several approved methods listed in 40 CFR Part 136, such as EPA Method 200.7 (inductively coupled plasma (ICP) atomic emission spectroscopy of trace elements) and Method 245.1 (mercury cold vapor atomic absorption technique). This method was developed specifically for the effluent guidelines program. EPA Method 1620 includes more metal analytes than are listed in the approved methods and contains quality control requirements at least as stringent as the approved methods in 40 CFR 136.

EPA Method 1620 employs the concept of an instrument detection limit (IDL). The IDL is defined as "the smallest signal above background noise that an instrument can detect reliably."[5] Data reporting practices for EPA Method 1620 analyses follow the conventional metals-reporting practices used in other EPA programs, in which values are required to be reported at or above the IDL. In applying EPA Method 1620, IDLs are determined on a quarterly basis by each analytical laboratory and are, therefore, laboratory-specific and time-specific. Although EPA Method 1620 contains MLs, the MLs predate EPA's recent refinements of the ML concept described earlier. The ML values associated with EPA Method 1620 are based on a consensus opinion reached between EPA and laboratories during the 1980s regarding levels that could be considered reliable quantitation limits when using EPA Method 1620. These limits do not reflect advances in technology and instrumentation since the 1980s. Consequently, the IDLs were used as the lowest values for reporting purposes, with the general understanding that reliable results can be produced at or above the IDLs. Though the baseline values were derived from the MLs (or adjusted MLs) in EPA Method 1620, EPA used the laboratory-reported quantitated values and sample-specific quantitation limits, which captured concentrations down to the IDLs, in its data analyses.

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[5] Keith, L.H., W. Crummett, J. Deegan, R.A. Libby, J.K. Taylor, G. Wentler (1983). "Principles of Environmental Analysis," Analytical Chemistry, Volume 55, Page 2217.

In general, EPA used the MLs specified in Method 1620 as the baseline values. However, EPA adjusted the baseline value for lead to 50 micrograms per liter (μg/L) and boron to 100 μg/L. In EPA Method 1620, lead has an ML of 5 μg/L for graphite furnace atomic absorption (GFAA) spectroscopy analysis; EPA determined, however, that it was not necessary for the laboratories to measure down to such low levels and that lead could be analyzed by ICP spectroscopy.[6] Consequently, the ML requirement was adjusted to 50 μg/L, the ML for the ICP method. In EPA Method 1620, boron has an ML of 10 μg/L, but laboratory feedback years ago indicated that laboratories could not reliably achieve this low level. As a result, EPA requires laboratories to measure values at only 100 μg/L and above. Thus, EPA adjusted the baseline value to 100 μg/L.

A.4.3 Methods 350.1, 350.2, 350.3, 4500-NH_3 B, SM4500-NH_3 C, SM4500-NH_3 D, SM4500-NH_3 E, SM4500-NH_3 F, and SM4500 NH_3-G (Ammonia as Nitrogen)

For EPA sampling episodes, ammonia as nitrogen was measured using Method 350.2, which is listed as approved for compliance monitoring in 40 CFR 136. Industry supplied data generated by 350.1, 350.3, SM4500-NH_3 B, SM4500-NH_3 C, SM4500-NH_3 D, SM4500-NH_3 E, SM4500-NH_3 F, and SM4500-NH_3 G. All of the methods used by the industry to determine ammonia as nitrogen are approved in 40 CFR 136, except for SM4500-NH3 D.

Method 350.2 utilizes either colorimetric, titrimetric, or electrode procedures to measure ammonia. SM4500-NH3 B is a preliminary distillation procedure used to separate the ammonia from sample matrix interferences. Method 350.1 is an automated colorimetric method that uses a continuous flow analytical system; SM4500-NH_3 C is colorimetric; SM4500-NH3 D is a phenate method; SM4500-NH_3 E is titrimetric; and 350.3 and SM4500-NH_3 F & G are potentiometric methods that all measure ammonia.

Method 350.2 has a lower measurement range limit of 0.20 milligrams per liter (mg/L) for the colorimetric and electrode procedures and a lower measurement range limit of 1.0 mg/L for the titrimetric procedure. Rather than using different baseline values for the same pollutant,

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[6] Also antimony, arsenic, selenium, and thallium were analyzed by ICP instead of GFAA. The method MLs were used because the laboratories demonstrated that their IDLs were able to quantitate below the ML for these four analytes.

EPA used the 0.20 mg/L because it represented a value at which ammonia as nitrogen can be measured reliably by several determinative techniques in Method 350.2, as well as in other approved methods in 40 CFR 136.

A.4.4 Methods 405.1 and SM5210 B (BOD_5, Carbonaceous BOD_5, and Dissolved BOD_5)

Biochemical oxygen demand (BOD_5), carbonaceous BOD_5 ($CBOD_5$), and dissolved BOD_5 ($DBOD_5$) were measured using Method 405.1 and Standard Method (SM) 5210 B, both of which are approved for compliance monitoring in 40 CFR 136. BOD_5 and $CBOD_5$ are essentially the same method, except an organic compound is added to the $CBOD_5$ test to inhibit nitrogenous oxygen demand. If the sample does not include any nitrogenous demand to inhibit, the results should be comparable for BOD_5 and $CBOD_5$. BOD_5 and dissolved BOD_5 are the same method, except that the dissolved BOD_5 sample is filtered prior to analysis (either in the field or immediately upon receipt by the laboratory).

Method 405.1 and SM5210 B are identical and the nominal quantitation limit, expressed in the methods as the lower limit of the measurement range at 2 mg/L, is the same for all three forms of BOD_5. EPA used this nominal quantitation limit of 2 mg/L as the baseline value in determining the pollutants of concern.

A.4.5 EPA Method 632 (Carbaryl)

Carbaryl was determined by EPA Method 632. No methods approved for carbaryl are given in 40 CFR 136. However, Method 632 is approved for compliance monitoring of carbaryl for the Pesticide Chemicals Point Source Category (see Table 7 in 40 CFR 455).

In this method, samples are prepared by liquid-liquid extraction with methylene chloride in a separatory funnel. The extract is analyzed by a high-pressure liquid chromatograph with an ultraviolet (UV) detector. The nominal quantitation limit was determined by a low-point calibration standard. The nominal quantitation limit for carbaryl is 1 µg/L, which was used as the baseline value.

A.4.6 Methods 410.1, 410.2, 410.4, SM5220 B, SM5220 C, and HACH 8000 (Chemical Oxygen Demand)

EPA determined chemical oxygen demand (COD) using Methods 410.1, 410.2, 410.4, and SM5220 B. Industry determined COD using SM5220 C and HACH 8000. Methods 410.1, 410.2, 410.4, SM5220 C and HACH 8000 are approved for compliance monitoring in 40 CFR 136.

Methods 410.1, 410.2, and SM5220 C are titrimetric procedures that follow identical analytical protocols and differ only in the range of COD concentrations that they are designed to measure. Reagent concentrations and sample volumes are adjusted to accommodate a wide range of sample concentrations, because the dynamic range of the chemistry used to detect COD is somewhat limited. Standard Method 5220 B is a titrimetric method that incorporates the different reagent concentrations and sample volumes listed in Methods 410.1 and 410.2 into one method. Data from all three of these methods are directly comparable. Method 410.4 is a colorimetric procedure. The HACH 8000 method is a colorimetric procedure that utilizes a preliminary digestion procedure and can be used for various concentration ranges.

Methods 410.1 and SM5220 C are designed to measure mid-level concentrations (greater than 50 mg/L) of COD and are associated with a nominal quantitation limit of 50 mg/L. Method 410.2 is designed to measure low-level concentrations of these parameters in the range of 5 to 50 mg/L. Method 410.4 has a measurement range of 3 to 900 mg/L for automated procedures and a measurement range of 20 to 900 mg/L for manual procedures. The HACH 8000 method has a lower measurement limit of 3.0 mg/L. EPA contracts required laboratories to measure down to the lowest quantitation limit possible regardless of the method used. Therefore, if the laboratory analyzed a sample using Method 410.1 and obtained a non-quantitated result, it had to reanalyze the sample using Method 410.2. Thus, the quantitation limit reported for non-quantitated results was equal to 5 mg/L, unless sample dilutions were required for complex matrices.

For all COD data, EPA used the baseline value of 5 mg/L, which is associated with the lower quantitation limit for the titrimetric procedures because most of the data used to determine the pollutants of concern had been obtained by the titrimetric procedures (Methods 410.1, 410.2, or SM5220 B).

A.4.7 Methods 325.3 and 300.0 (Chloride)

Chloride was measured using Method 325.3, which is approved for compliance monitoring in 40 CFR 136, and Method 300.0, which is not listed in 40 CFR 136. Method 325.3 is a colorimetric (actually titrimetric) procedure and measures concentrations greater than 1 mg/L. Method 300.0 uses ion chromatography and can measure to levels as low as 0.05 mg/L. EPA allowed laboratories to use Method 300.0 even though it is not approved at 40 CFR 136 because the analytical methods normally used for chloride are subject to interferences sometimes present in samples containing blood, animal tissue, or other particulates. With Method 300.0, the complex matrices are not a factor and this method has a lower nominal quantitation limit than Method 325.3. (Section A.4.10 provides a more detailed description of Method 300.0.)

For all chloride data, EPA used the baseline value of 1 mg/L, which is associated with the higher quantitation limit for the colorimetric procedure because most of the data used in the pollutants of concern analysis had been obtained by the colorimetric procedure (Method 325.3).

A.4.8 EPA Method 1657 (Dichlorvos, Malathion, Tetrachlorvinphos)

Laboratories used Method 1657 to measure dichlorvos, malathion, and tetrachlorvinphos concentrations in the samples. There is one approved method for malathion at 40 CFR 136 – SM6630C; however, the other two pesticides are not listed in 40 CFR 136. EPA Method 1657 was selected for analysis of all three pesticides for several reasons, including the following:

- Method 1657 is approved for compliance monitoring of all three pesticides for the Pesticide Chemicals Point Source Category (see Table 7[7] in 40 CFR 455).
- EPA 1600-series methods were developed specifically for the effluent guidelines program; therefore, they have more stringent quality control requirements than Standard Methods.
- It was more economical to use one method for the three pesticides than to analyze malathion separately by SM6630C.

[7] Table 7 lists tetrachlorvinphos as stirofos.

In Method 1657, samples are prepared by liquid-liquid extraction. The extract is dried and concentrated and a 1-µL aliquot of the extract is injected into the gas chromatography equipment. The nominal quantitation limit of 2 µg/L was used as the baseline value for all three pesticides. This nominal quantitation limit was determined from the results of low-point calibration standards.

A.4.9 Methods 365.2, 365.3, 365.4, SM4500-P B, SM4500-P E, and HACH 8190 (Dissolved Total Phosphorus and Total Phosphorus)

EPA determined dissolved total phosphorus and total phosphorus by Methods 365.2 and 365.3. Industry determined total phosphorus by Methods 365.4, SM4500-P B, SM4500-P E, and HACH 8190. Methods 365.2, 365.3, 365.4, SM4500-P B, and SM4500-P E are approved for compliance monitoring of total phosphorus at 40 CFR 136. HACH 8190 is a colorimetric method that is considered to be a comparable version of Method 365.2. Total phosphorus represents all of the phosphorus present in the sample, regardless of form, as measured by the persulfate digestion procedure. Dissolved phosphorus results were obtained by filtering the sample prior to this step.

Methods 365.2 and 365.3 are spectrophotometric methods that differ from each other only in the preparation of one of the reagents. Method 365.2 specifies the separation of the ammonium molybdate and the antimony potassium tartrate from the ascorbic acid reagent, while Method 365.3 allows for the combining these reagents into a single solution. Because the chemistry is unaffected, data from the two methods are directly comparable. Method 365.4 is an automated colorimetric method. SM4500-P B is the sample digestion step used with SM 4500-P E, a spectrophotometric method comparable to Method 365.2.

These methods have the same nominal quantitation limit, 0.01 mg/L, for both analytes. EPA used this value as the baseline value for both dissolved total phosphorus and total phosphorus.

A.4.10 Methods 300.0, 352.1, 353.1, 353.2, 354.1, SM4500-NO_2 B, SM4500NO_3-D, and SM4500-NO_3 E (Nitrate/Nitrite)

For EPA sampling episodes, nitrate/nitrite was measured by Methods 300.0, 353.1, and 353.2. For industry-supplied data, nitrate/nitrite was measured by Methods 352.1, 354.1, SM4500-NO_2 B, SM4500-NO_3 D, and SM4500-NO_3 E. All of these methods, except for Methods 300.0 and SM4500-NO3 D, are approved for compliance monitoring in 40 CFR 136. Because nitrate/nitrite is a component of total nitrogen (see Section A.5), EPA considered approving EPA Method 300.0 at 40 CFR Part 432 for compliance monitoring of nitrate/nitrite or amending 40 CFR Part 136 to include Method 300.0 for determination of nitrate/nitrite from wastewaters. In the preamble to the MPP proposed rule, EPA requested comments on the use of this method for the MPP point source category and whether the method should be approved and included in 40 CFR Part 432, 40 CFR Part 136, or both. EPA did not receive any comments on this topic. EPA is planning to propose a rule to amend 40 CFR Part 136 to include Method 300.0 for determining nitrate/nitrite in wastewater.

Many of the approved analytical methods for nitrite/nitrate in 40 CFR 136, including Methods 352.1, 353.1 and 353.2, are based on colorimetric techniques (adding to a sample reagents that form a colored product when they react with the nitrate/nitrite and then measuring the intensity of the colored product). Such methods can be subject to interferences in the complex matrices associated with this industry, where samples may contain blood, animal tissue, or other particulates that affect both the color development and ability to pass light through the sample to measure the intensity of the colored product. In contrast, Method 300.0 employs the technique known as ion chromatography to measure 10 inorganic anions, including nitrate and nitrite. Ion chromatography permits the various inorganic anions to be separated from one another as well as from other materials and contaminants present in the sample. Each anion can be identified on the basis of its characteristic retention time (the time required to pass through the instrumentation). After separation, the anions are measured by a conductivity detector that responds to changes in the effluent from the ion chromatograph–changes that occur when the negatively charged anions (analytes) elute at characteristic retention times, thereby changing the conductivity of the solution. Thus, Method 300.0 offers better specificity for nitrate and nitrite in the presence of

interferences compared with the approved colorimetric methods. Method 300.0 is included in the rulemaking record (Docket No. W-01-06, Record No. 10036).

Methods 353.1 and 353.2 are essentially the same method, with variations in the technique used to reduce the nitrite (NO_2) present in the sample to nitrate (NO_3). Method 353.1 uses hydrazine to accomplish the reduction, while Method 353.2 uses cadmium granules. Method 353.2 is typically preferred simply because the cadmium granules are far easier to handle and less toxic than hydrazine. The chemistry of the colorimetric determination is the same, as are the interferences. SM4500-NO_3 E is a manual cadmium reduction method that is similar to Method 353.3. The reduction methods convert all of the nitrate into nitrite and measure total nitrite concentration.

Methods 354.1 and SM4500-NO_2 B directly measure nitrite. These methods are essentially the same as the oxidized nitrogen methods, but without the reduction. Methods 352.1, SM4500-NO_3 D, and 300.0 directly measure nitrate. Method 352.1 uses the colorimetric reaction of brucine sulfate with nitrate to form a color that is proportional to the nitrate concentration. SM4500-NO_3 D uses a nitrate electrode to measure nitrate. Method 300.0 is detailed above.

Each of the methods lists slightly different nominal quantitation limits that are expressed in the methods as the lower limit of the measurement range. The nominal quantitation limit for Methods 300.0, 353.1, 354.1, and SM4500-NO_3 E is 0.01 mg/L. The nominal quantitation limit for Method 353.2 is 0.05 mg/L, and for 352.1 is 0.1 mg/L. The nominal quantitation limit for SM4500-NO_2 B is 0.005 mg/L and for SM4500-NO_3 D is 0.14 mg/L. Rather than use different baseline values for the same pollutant, EPA used the nominal quantitation limit of 0.05 mg/L from Method 353.1 as the baseline value for nitrate/nitrite. EPA chose this value because Method 353.1 was used to obtain most of the data used in the pollutants of concern analysis. This value is also the maximum of the nominal quantitation limits from the methods used by EPA.

A.4.11 Methods 413.1, SM5520 B, and SM5520 D (Oil and Grease)

Industry determined oil and grease by Methods 413.1, SM5520 B, and SM5520 D. Methods 413.1 and SM5520 B are listed as approved methods for compliance monitoring in 40 CFR 136, whereas SM5520 D is not listed there. Methods 413.1 and SM5520 B are gravimetric

methods. SM5520 D is a soxhlet extraction method. Method 413.1 has a lower limit measurement range of 5.0 mg/L, and SM5520 B and SM5520 D have a lower limit measurement range of 10 mg/L. EPA used the nominal quantitation limit of 5.0 mg/L from EPA Method 1664A as the baseline value.

A.4.12 Method 160.1 (Total Dissolved Solids)

Total dissolved solids (TDS) was measured by Method 160.1, which is approved for compliance monitoring in 40 CFR 136 (see 'residue – filterable'). Method 160.1 is a gravimetric method with a lower limit measurement range of 10 mg/L. EPA used this nominal quantitation limit of 10 mg/L as the baseline value.

A.4.13 Methods 351.2, 351.3, SM4500-Norg B, and SM4500-NH_3 E (Total Kjeldahl Nitrogen)

For EPA sampling episodes, total Kjeldahl nitrogen (TKN) was measured by Methods 351.2 and 351.3. For industry supplied data, TKN was measured by SM4500-Norg B and SM4500-NH_3 E. All of these methods are approved for compliance monitoring in 40 CFR 136.

Method 351.2 is designed to be used with a flow colorimetry apparatus with a lower measurement range limit of 0.1 mg/L. Method 351.3 is a manual colorimetric analysis that has a lower measurement range limit of 0.5 mg/L. SM4500-Norg B is the sample preparation method and SM4500-NH_3 E is the determinative method for TKN. SM4500-Norg B and SM4500-NH_3 have a lower measurement range of 5 mg/L. Rather than use different baseline values for the same pollutant, EPA used the nominal quantitation limit of 0.5 mg/L from Method 351.3 as the baseline value for TKN. EPA chose this value because Method 351.3 was used by EPA to obtain most of the data used in the pollutants of concern analysis. This value is also the maximum of the nominal quantitation limits from the two methods used by EPA.

A.4.14 Method 415.1 (Total Organic Carbon)

Total organic carbon (TOC) was determined by Method 415.1, which is approved for compliance monitoring in 40 CFR 136. Method 415.1 is a combustion (or oxidation) method

with a lower measurement range limit of 1 mg/L. EPA used this nominal quantitation limit of 1 mg/L as the baseline value.

A.4.15 Methods 365.2 and 300.0 (Total Orthophosphate)

Methods 365.2 and 300.0 were used to measure orthophosphate concentrations. Total orthophosphate is the inorganic phosphorus (PO_4) in the sample. Method 365.2 is approved for compliance monitoring of total orthophosphate in 40 CFR 136, while Method 300.0 is not. As explained previously (see Sections A.4.7 and A.4.10), EPA allowed laboratories to use Method 300.0 because interferences sometimes present in samples containing blood, animal tissue, or other particulates are not a factor in the analysis.

Method 365.2 is a colorimetric method for determining orthophosphate and measures concentrations greater than 0.01 mg/L. Method 300.0 uses ion chromatography and can measure down to 0.20 mg/L. For all orthophosphate data, EPA used the baseline value of 0.01 mg/L, which is associated with the lower quantitation limit for the colorimetric procedure because the laboratories used Method 365.2 to produce the majority of the data used in the pollutants of concern analysis.

A.4.16 Methods HACH 8167 and 330.5 (Total Residual Chlorine)

Total residual chlorine was determined by Methods 330.5 and HACH 8167. Method 330.5 is approved for compliance monitoring in 40 CFR 136. Methods 330.5 and HACH 8167 use the same colorimetric reagent, N,N-diethyl-p-phenylene diamine (DPD), and are essentially the same procedure; thus, the data are directly comparable.

The nominal quantitation limit in Method 330.5 is 0.2 mg/L; the nominal quantitation limit for method HACH 8167 is 0.1 mg/L. Rather than use two different baseline values for the same pollutant, EPA used the value associated with Method 330.5 (0.2 mg/L) as the baseline value because Method 330.5 was used to produce the majority of the data used in the pollutants of concern analysis. The Method 330.5 baseline value also is the higher of the two values.

A.4.17 Method 160.2 and SM2540 D (Total Suspended Solids)

For EPA sampling episodes, total suspended solids (TSS) was determined using Method 160.2. For industry supplied data, TSS was measured by SM2540 D. Both methods are approved for compliance monitoring in 40 CFR 136. Both methods are gravimetric with a lower limit measurement range of 4 mg/L. The nominal quantitation limit of 4 mg/L was used as the baseline value.

A.4.18 Method 160.4 (Volatile Residue)

Volatile residue was determined by Method 160.4, which is approved for compliance monitoring in 40 CFR 136. Method 160.4 is a gravimetric and ignition method with a lower limit measurement range of 10 mg/L. The nominal quantitation limit of 10 mg/L was used as the baseline value.

A.4.19 EPA Method 1622 (*Cryptosporidium*)

Cryptosporidium was determined by EPA Method 1622, which, as explained in Section A.1, has not been approved for compliance monitoring. However, Methods 1622 and 1623 are 40 CFR Part 136-approved methods for *Cryptosporidium* for ambient water monitoring, published on July 21, 2003 (68 *Federal Register* (FR) 139, pages 43272–43283; correction notice in 68 FR 182 page 54934). In Method 1622, the laboratory filters a 10-liter sample through an absolute-porosity filter to capture any target organisms that may be present, elutes the filter, concentrates the eluate, purifies the concentrate using immunomagnetic separation, and applies the purified sample to a microscope slide. The purified sample is stained with an antibody stain and a vital dye stain, and target organisms are identified and counted based on immunofluorescence assay, differential interference microscopy, and vital dye staining characteristics.

Due to the high turbidity of the sample matrices for these episodes, it was necessary for the analytical laboratory to modify the sample processing steps of the method, depending on the nature of the particulates in the sample. For samples that contained a high concentration of biological particles, a small volume of the sample (100 to 250 milliliters (mL)) was concentrated using centrifugation and then processed according to EPA Method 1622. For samples with lower

concentrations of biological particulates that could be filtered, a 10-liter sample was filtered through a compressed foam filter, the filter was eluted, and the eluate was concentrated by centrifugation and then processed according to EPA Method 1622.

As explained earlier, there is no detection limit or baseline value associated with EPA Method 1622; however, EPA used the baseline value of zero in the pollutant of concern analysis. Furthermore, if *Cryptosporidium* was not quantitated, the sample was reported as zero.

A.4.20 SM9221B, SM9221C, SM9221D, SM9221E, SM9221F, SM9230B, SM9260L, FDA-BAM Chapter 5 (Total Coliform, Fecal Coliform, *E. coli*, Fecal Streptococcus, *Aeromonas*, *Salmonella*)

Laboratories measured the densities of total coliform, fecal coliform, *E. coli*, fecal streptococcus, *Aeromonas*, and *Salmonella* in 100-milliliter samples using the multiple-tube fermentation procedures specified in *Standard Methods* and the Food and Drug Administration's *Biological Analytical Manual* (FDA-BAM). EPA used methods approved for compliance monitoring in 40 CFR 136 for total coliform (SM9221B), fecal coliform (SM9221C,D,E), and fecal streptococcus (SM9230B). At the time of the sampling there were no methods approved in 40 CFR 136 for *E. coli*, *Aeromonas*, and *Salmonella*; however, EPA published final ambient water monitoring methods for *E.coli* on July 21, 2003 (68 FR 139, pages 43272–43283; correction notice in 68 FR 182, page 54934). The method used for *E. coli*, SM9221F, is now an approved method in Part 136.

To measure total coliform (SM 9221B), fecal coliform (SM 9221C,D,E), and *E. coli* (SM 9221F), samples were inoculated into a presumptive medium (lauryl tryptose broth) and incubated. Tubes positive for growth and gas production were transferred into confirmatory media: brilliant green bile broth (for total coliform), EC (for fecal coliform), or EC-MUG (for *E. coli*). Tubes with growth and gas production in their respective media were recorded as positive.

To measure fecal streptococcus (SM 9230B), samples were inoculated into a presumptive medium (azide dextrose broth) and incubated. Tubes positive for turbidity (growth) were confirmed by streaking onto bile esculin agar plates. All plates with typical growth were recorded as positive for fecal streptococcus.

Aeromonas densities were determined using SM 9260L, followed by the confirmation steps in EPA Method 1605 to minimize false positive results. Samples were inoculated into a presumptive medium (TSB30) and incubated. Tubes with growth were streaked onto ampicillin-dextrin agar (ADA). All yellow colonies were isolated on nutrient agar and confirmed as *Aeromonas* if they were oxidase positive and were able to ferment trehalose. In addition to the biochemical confirmation, colony morphologies from ADA and nutrient agar were recorded and used to differentiate between *Aeromonas* and *Bacillus*.

The FDA-BAM Chapter 5 method was used to determine *Salmonella* densities. Samples were inoculated into a presumptive medium (tetrathionate broth) and incubated. Tubes with growth were streaked onto Hektoen enteric agar plates. Typical colonies were confirmed on triple sugar iron agar slants. The FDA-BAM method was used instead of the approved Kenner-Clark method because the performance of the FDA-BAM method is better suited for samples that contain blood and particulates.

The nominal quantitation limit for these analytes was determined using the most probable number (MPN) approach specified in *Standard Methods*. The MPN of each target organism per 100 milliliters was calculated based on the positive and negative results from the analysis of multiple replicates at multiple dilutions for each sample (see Table 9221.IV of *Standard Methods* and Table 2 in Appendix 2 of FDA-BAM). Based on the tables in *Standard Methods*, the nominal quantitation limit for all analytes was 2 MPN per 100 mL. The nominal quantitation limit was used as the baseline value. No values were reported below the baseline value.

A.4.20.1 Holding Time Study

When EPA conducted its own sampling episodes at the facilities, it exceeded the required holding time for some samples. Although laboratories qualified to conduct total coliform, fecal coliform, and *E. coli* analyses might have been within driving distance of the facilities being evaluated, laboratories qualified to perform fecal streptococcus, *Salmonella*, and *Aeromonas* analyses generally were not available, because analysis for these analytes is more complex than coliform analyses. As a result, for most sampling episodes, EPA decided to ship samples overnight to a laboratory capable of performing all of the bacterial analyses. Because these

samples would exceed the holding time requirements in 40 CFR 136, EPA performed a holding time study to evaluate the possible effects of analyzing samples at different holding times.

To determine whether or not the results for samples with longer holding times were consistent with results for samples analyzed within 8 hours (i.e., the time period consistent with 40 CFR 136 for compliance sampling), for total coliforms, fecal coliforms, *E. coli*, *Aeromonas*, fecal streptococcus, and *Salmonella* from MPP facilities, EPA conducted a holding time study to evaluate sample concentrations at 8, 24, 30, and 48 hours after sample collection for wastewater effluent samples from a beef facility (before disinfection and final effluent), a pork facility (final effluent prior to discharge into the sewer system), and a poultry facility (final effluent). The study report, which contains results for all target bacteria, is DCN 165311 in Section 22.6 in the public record for the Notice of Data Availability (NODA). Only the results for fecal coliform and *E. coli* are discussed here, because EPA is not establishing numeric limitations for other target indicators in the holding time study. As holding times increase, the fecal coliform and *E. coli* concentrations may change. EPA's intent in conducting the study was to gain some insight into the length of time that would still provide results comparable to the results for samples held for eight hours.

For red meat effluent, the results of this study indicate that samples for fecal coliform and *E. coli* measurements can be held for 24 hours and still produce results comparable to analyses conducted at 8 hours after sample collection, provided that samples are stored on ice until analysis and not frozen. For poultry wastewater effluent, the study results indicate that samples held longer than 8 hours do not provide comparable results to results at 8-hour holding times.

For red meat facilities where EPA is retaining the previously promulgated limitations and standards, EPA is using the fecal coliform data from the EPA sampling episodes for some analyses such as (1) calculations for loadings and (2) evaluation of treatment performance by comparing influent and effluent data. For the treatment technologies that EPA considered, all of the red meat data from sampling episodes are associated with holding times of about 24 hours. Based on the results of the holding time study, EPA is using the 24-hour data for these analyses. Note that EPA is not revising the current limitations and standards for red meat facilities and thus is not using these data to develop limitations and standards for fecal coliform. In the NODA,

EPA requested comments on the use of the 24-hour holding time data for analysis of loadings and treatment performance at red meat facilities. EPA did not receive any comments in response to the solicitation in the NODA.

For poultry facilities, where EPA transferred the existing limitations and standards from the red meat subcategories, EPA used only data within the 8-hour holding time for its loading analysis because the holding time study indicated that longer holding times for poultry processing wastewaters were not comparable to the 8-hour period. Because only one sampling episode (6304) meets this criterion, EPA based its loadings and other analyses on fecal coliform data from this single sampling episode and any appropriate self-monitoring data. EPA used these data in evaluating the achievability of the limitations that EPA transferred from the existing limitations for the red meat subcategory. EPA received comments on the transfer of limitations for the poultry subcategory from the red meat subcategory, and on its planned use of data to analyze loadings and treatment performance.

A.4.20.2 Monitoring of E. coli and Fecal Coliform

Although EPA considers fecal coliform to be the appropriate parameter for regulation for the MPP industry, EPA recognizes that some states and tribes may still prefer that facilities monitor directly for *E. coli*. Because concentrations of fecal coliform and *E. coli* might be similar in these matrices, EPA is considering an alternative that would allow facilities to monitor *E. coli* instead of fecal coliform in the effluent. This alternative would be available when EPA amends 40 CFR 136 to include an analytical method for *E. coli* in industrial effluent. EPA expects to promulgate such a method in the next few years. EPA is conducting validation studies of this method and expects to propose this method in 2004. See Vol. 68, No. 156 of the Federal Register for more detail.

A.4.20.3 Reporting Units

EPA received comments requesting that the Agency allow for monitoring of fecal coliforms to be reported in colony forming units (CFU) per 100 milliliters in addition to most probable numbers (MPN) per 100 mL as specified in the existing regulations. Based on the research of Thomas and Woodward in *Estimation of Coliforms Density by the Membrane Filter*

and the Fermentation Tube Methods, results from either technique can be considered comparable as long as the volume analyzed is equivalent. This finding of comparability is consistent with documentation for the existing fecal coliform limitations and standards. Therefore, EPA is revising the limitations and standards to allow for fecal coliform results to be reported in units of either MPN per 100 mL or CFU per 100 mL, based on the analytical method used to determine the results. Specifically, fecal coliform results should be reported in MPN per 100 mL if the multiple-tube format is used; and in CFU per 100 mL if the membrane filtration (MF) technique is used. According to SM 9222A and SM 9222B, although statistical comparisons show the MF technique to be more precise than the multiple-tube procedure, data generated from the MF and the multiple-tube test yield approximately the same water quality information.

A.5 Total Nitrogen

EPA is regulating total nitrogen to ensure that the relationship between organic nitrogen (estimated by TKN) and inorganic nitrogen (estimated by nitrate/nitrite) is maintained. EPA is defining “total nitrogen” to be the sum of nitrate/nitrite and TKN for the purposes of the MPP industry. This summation includes nitrogen in the trinegative oxidation state (the dominant oxidation state of nitrogen in organic compounds), ammonia-nitrogen, and nitrogen in nitrite (NO_2^-) and nitrate (NO_3^-). In developing the limitations (see Section 14), EPA used a baseline value of 0.1 mg/L, which is the sum of the baseline values for nitrate/nitrite (0.05 mg/L) and TKN (0.05 mg/L).

APPENDIX B

SURVEY DESIGN AND CALCULATION OF NATIONAL ESTIMATES

In 2001, EPA distributed two industry surveys. The first survey, entitled 2001 Meat Products Industry Screener Survey (short survey), was mailed to 1,650 meat products industry facilities. The second survey, entitled 2001 Meat Products Industry Survey (detailed survey), was mailed to 350 meat products industry facilities.

Section B.1 of this appendix describes the survey design (identification of facilities in the industry and sample design). Section B.2 of this appendix describes the selection of the sample. Section B.3 of this appendix describes response status of short survey facilities. Section B.4 of this appendix describes the calculation of sample weights. Section B.5 of this appendix describes the methodology for estimating national totals and their variance estimates. Section B.6 of this appendix summarizes EPA's analysis of the detailed survey.

B.1 SURVEY DESIGN

This section describes the development of the sampling plan, which includes identification of the meat products industry and stratification of facilities.

B.1.1 Sample Frame

To produce a mailing list of facilities for the detailed survey and short survey, EPA developed a sample frame of the meat products industry. A sample frame is a list of all members (sampling units) of a population, from which a random sample of members will be drawn for the survey. Therefore, a sample frame is the basis for the development of a sampling plan to select a random sample. EPA used several data sources to construct this sample frame. The March 2000 Hazard Analysis and Critical Control Points (HACCP) database was the main source of data. It was supplemented with information from the Urner-Barry Meat and Poultry Directory 2000 and an April 2000 list of 236 renderers provided by the National Renderers Association (NRA). The sample frame for the meat product survey contained 8,217 facilities.

EPA classified each facility into sampling strata by considering facility type, facility size, and type of animal used at the facility. Each facility was of one of the following three types: first processor, further processor, or renderer. Three size categories were used to determine the facility size. The size category was defined as large for facilities with 500 employees or more, small for

facilities with 10 to 499 employees, and very small for facilities with 9 employees or less. Each facility on the sample frame specialized in one or several types of animal. These types of animal corresponded to poultry, beef, pork, and other. Renderers were not identified by size or animal type.

B.1.2 Sample Design

The sample frame for the survey included an unknown number of out-of-scope facilities. In order to obtain reliable counts of eligible meat product facilities, i.e., the facilities that were in-scope, by type and facility size directly from the frame, the survey was designed as a two-phase sample.

A first-phase sample of 2,000 facilities was selected from a sample frame containing 8,217 facilities. Additionally, a second-phase sample of 350 facilities was selected from the first-phase sample. All 350 second-phase sample facilities were mailed the detailed questionnaire, while the remaining 1,650 first-phase sample facilities received the short questionnaire. While the abridged form collected basic data to determine eligibility status and types of meat processed, the long form collected data about the 350 second-phase sample facilities for technical and financial information. Because of time constraints, both surveys were sent out simultaneously. To improve the accuracy of estimates from the detailed survey, the final weights were calibrated to the estimated counts of eligible facilities from the short survey.

EPA identified a list of 65 facilities that were to be selected for the second-phase detailed sample with certainty to obtain information necessary for evaluating facility operations and best technology options. The first-phase and second-phase facility samples were stratified samples. Stratification separated the eligible population into non-overlapping strata that were as homogeneous as possible. Stratification assured that the sample would contain the same proportions as found on the sample frame, for those variables used to define the strata. The first-phase sample (selecting 1,935 non-certainties from 8,152) was stratified by facility type and size. The stratification of the second-phase sample was based only on facility type, since just 285 facilities were to be selected from the 1,935 first-phase non-certainties.

Table B-1 shows the distribution of facilities on the sample frame by facility type (first processor, further processor, renderer, or missing), size, and certainty status. Most certainty facilities were large first processors. Only 5 certainty facilities were small and none of the very small facilities were included in the sample with certainty.

B.1.3 Imputing for Missing Facility Type

In order to estimate the number of eligible facilities by type, size, and meat product (the purpose of the short survey), it was necessary to include samples of sufficient size from each facility-type-by-size stratum. This required assigning each facility on the frame to one of these strata; however, this information was unknown for many facilities; thus, EPA imputed the missing stratification data.

Table B-1. Distribution of Facilities in the Sample Frame by Certainty, Facility Type, and Size

Certainty status	Facility type	Size				Total
		Large	Small	Very small	Unknown	
Non-certainties	First Processor	149	234	0	0	383
	Further Processor	34	883	0	0	917
	Renderer	0	0	0	235	235
	Unknown	50	1,259	5,308	0	6,617
Non-certainty total		233	2,376	5,308	235	8,152
Certainties	First Processor	56	3	0	0	59
	Further Processor	1	0	0	0	1
	Renderer	0	0	0	1	1
	Unknown	2	2	0	0	4
Certainty total		59	5	0	1	65
Grand total		292	2,381	5,308	236	8,217

From Table B-1 it is seen that facility type had to be imputed for 6,617 non-certainty facilities.[1] The facilities to be imputed a specific type were chosen randomly from the set of facilities with missing type. The facilities with unknown facility type were distributed between "first processors" and "further processors" proportionally to the reported number by type within

[1] It should be noted that no imputation was carried out on the four certainty facilities with missing facility type, as they were to be included in the sample by design.

each size category. Therefore, 9 (=50 x (34/(34+149))) of the 50 large facilities with missing facility type were assigned to the further processor category, while the remaining 41 large facilities were assigned to the "first processor" category. Similarly, 995 of the 1,259 small facilities with missing facility type were assigned the "further processor" type, and the remaining 264 small facilities were assigned the "first processor" type. All very small facilities were assumed to be further processors because very small facilities in this industry were typically further processors.

All imputed values were used only for allocating the sample. None of the values were used for estimation and any wrong assumption simply resulted in a less efficient sample (larger variance). In addition, this imputation process was not expected to introduce any bias in the statistical procedure. For example, all very small facilities were assumed to be further processors; however, if any very small facility reported as a first processor it was treated as such in all analyses.

B.1.4 Imputing for Missing Animal Type

Before selecting the samples, the frame was sorted by animal type within each stratum. This allowed for appropriate representation of the different animal types in random selection of the sample. Table B-2 shows the distribution by animal type of noncertainty facilities that were not renderers. It should be noted that the stratification did not require the specification of animal type for the renderers. All large facilities with missing animal type were randomly assigned to one of the 7 animal type categories described in Table B-2 proportionally to the large facilities with animal types reported in the frame. On the other hand, small and very small facilities were combined and randomly assigned to animal type groups proportionally to the number of small facilities reported with animal types.

Table B-2. Distribution of Noncertainty and Non-Renderer Facilities Imputed for Animal Type

Facility size	Animal type	Number of facilities reported on frame	Number of facilities imputed
Large	Pork only	17	4
	Poultry only	127	30
	Poultry & Pork	2	0
	Beef only	10	2
	Beef & Pork	6	1
	Beef & Poultry	3	2
	Beef & Poultry & Pork	23	6
	Missing	45	N/A
Small and very small	Pork only	157	805
	Poultry only	152	779
	Poultry & Pork	32	164
	Beef only	196	1,005
	Beef & Pork	203	1,041
	Beef & Poultry	76	390
	Beef & Poultry & Pork	438	2,246
	Missing	6,430	N/A
Total		7,917	6,475

B.2 SAMPLE SELECTION OF FACILITIES

The design of the first-phase sample was based upon the assumption that large facilities were more likely to be eligible than small facilities, which in turn were expected to be eligible more frequently than very small facilities. Thus, EPA determined that oversampling of the large facilities would be appropriate, in order to include many eligible facilities. Too much oversampling would reduce the accuracy of estimates because some facilities would have much greater weights than other facilities. An examination of alternative oversampling schemes[2] suggested balancing these two constraints by selecting large facilities at six times the rate of very small facilities, and at twice the rate of small facilities.

[2] July 28, 2000 memorandum from David Marker to Helen Jacobs and Jade Lee-Freeman.

After sorting by animal type, the facilities were selected from each stratum using systematic sampling scheme. Systematic sampling involve selecting every kth facility where k is determined by the selection rate. The allocation of the sample is described in Table B-3. The allocation in Table B-3 was based upon the 6-3-1 rule according to which, large facilities were selected at a rate that was 6 times higher than that of very small facilities and twice higher than that of small facilities. Using this allocation scheme, EPA selected a total of 2,000 facilities from the frame of 8,217 facilities.

Table B-3. Allocation of the First-Phase Sample

Stratum *h*	**Sample frame size** ***(N_h)***	**First phase sample size** ***(n_h)***
Certainty	65	65
Large First Processor	190	152
Large FurtherProcessor	43	34
Small First Processor	498	199
Small Further Processor	1,878	750
Very Small Further Processor	5,308	706
Renderer	235	94
Total	8,217	2,000

The 350 sample facilities were allocated in the second-phase sample to provide similar precision for each of seven analytic domains of interest. These domains were: poultry, beef, and pork first processors; poultry, beef, and pork further processors; and renderers. The 285 noncertainty sample facilities were therefore allocated so that approximately 41 (=285/7) were in each of these seven domains. The entire second-phase sample, including the noncertainty sample, consisted of 121 first processors, 122 further processors, and 42 renderers, along with 65 facilities selected with certainty. The facilities were sorted within facility type by animal type (as listed in Table B-4) before selecting the samples. Table B-4 shows how the first-phase sample in the previous table was distributed across the short and detailed surveys.

Table B-4. Allocation of the Sample to the Short and Detailed Surveys

Facility size and type	Sample size		
	First phase	Short survey	Detailed Survey
Certainty	65	0	65
Large First processor	152	100	52
Large Further processor	34	31	3
Small First processor	199	130	69
Small Further processor	750	688	62
Very small Further processor	706	649	57
Renderer	94	52	42
Total	2,000	1,650	350

For the purpose of selecting the sample of facilities, the WESSAMP SAS macro developed at Westat was used. WESSAMP selects systematic samples within sampling strata defined through a set of parameters.

B.3 RESPONSE STATUS OF SHORT (SCREENER) SAMPLE FACILITIES

Of the 1,650 facilities to which a short form was mailed, 173 did not return the form and as of December 31, 2002 eligibility was unknown for 157 of them. The remaining 16 were known to be eligible non-respondents. EPA also assumed that some of the 157 facilities with unknown eligibility were eligible non-respondents. A total of 286 facilities that were either out-of-scope or could not be located were classified as ineligible. The remaining 1,191 facilities were eligible respondents. These were facilities that returned a complete form and indicated that they engaged in meat processing. The short survey weights were constructed for a total of 1,254 eligible respondents. This includes 63 certainty facilities that completed the detailed survey questionnaire. They are included in the weighting for both surveys to allow national estimates to be produced from either set of respondents. Thus, the short survey weights were constructed using the 1,191 eligible short survey respondents, and 63 “shadow” facilities corresponding to the 63 certainty facilities that were eligible to be detailed survey respondents.

Table B-5 shows the response status by stratum for the 1,650 facilities that were mailed the short survey (excluding the 63 shadow facilities).

Table B-5. Response Status for the Short Survey by First-Phase Stratum

Stratum	Sample size	Eligible Respondent (S_1)	Non-respondent		Ineligible	
			Known Eligibility (S2)	Unknown Eligibility (S4)	Out-of-Scope (S_3)	Non-deliverable
Large First Processor	100	97	1	1	1	0
Large Further Processor	31	28	0	1	2	0
Small First Processor	130	101	1	9	15	4
Small Further Processor	688	498	7	59	73	51
Very Small Further Processor	649	435	7	85	57	65
Renderer	52	32	0	2	5	13
Total	1,650	1,191	16	157	153	133

B.4 WEIGHTING OF THE SHORT SURVEY

This section describes the methodology used to calculate the base weights, non-response adjustments, and the final weights for the short survey. In its analysis, EPA applied sample weights to survey data. The short survey was weighted in order to account for variable probabilities of selection, differential response rates, and ineligible facilities. The base weights and non-response adjustments reflect the probability of selection for each facility and adjustments for facility level non-responses, respectively. Weighting the data allows inferences to be made about all eligible facilities, not just those included in the sample, but also those not included in the sample or those that did not respond to the survey. Also, the weighted estimates have a smaller variance than unweighted estimates (see Section B.5 of this appendix for variance estimation.)

B.4.1 Base Weight Calculation

The first step in weighting the short survey was to assign a base weight to each of the sample facilities. The base weight associated with a short survey facility was calculated by multiplying the reciprocal of the probability of including that facility in the first-phase sample of 2,000 facilities, by the reciprocal of the probability of not including that facility in the detailed survey sample in the second phase. Table B-6 shows the calculation of the base weight. The short

survey base weight for a given first-phase stratum *h* and second-phase stratum *l* can formally be written as follows:

$$Base\ weight_{hl} = \left(\frac{n_h}{N_h}\right)^{-1} \times \left(1 - \frac{m_l}{M_l}\right)^{-1}$$

where N_h is the number of facilities in the sample frame that belong to first-phase stratum *h*, n_h is the number of facilities selected in the first-phase sample that belong to first-phase stratum *h* (N_h and n_h are shown in Table B-5), M_l is the number of first-phase sample facilities that belonged to second-phase stratum *l*, and m_l is the number of facilities selected in the detailed survey sample from second-phase stratum *l*.

For example, in the first-phase sample, 34 of 43 large further processors were selected, so the first-phase inclusion probability was 0.7907. The second-phase sample only stratified by facility type, so the second-phase inclusion probability for further processors in the detailed survey was (3 + 62 + 57)/(34 + 750 + 706) = 0.0819 (see Table B-4). The overall inclusion probability for the short survey was (0.7907) x (1 - 0.0819) = 0.72596. The base weight was the reciprocal of this probability, i.e., reciprocal of 0.72596, which is 1.3775.

Table B-6. Base Weight Calculation for the Short Survey

Stratum	First-phase inclusion probability (n_h/N_h)	Second-phase detailed survey inclusion probabilities (m_l/M_l)	Short survey inclusion probabilities $\left(\frac{n_h}{N_h}\left(1-\frac{m_l}{M_l}\right)\right)$	Short survey base weights $\left(\left(\frac{n_h}{N_h}\right)^{-1}\times\left(1-\frac{m_l}{M_l}\right)^{-1}\right)$
Large First processor	0.8000	0.3447	0.52422	1.9076
Small First processor	0.3996	0.3447	0.26185	3.8191
Large Further processor	0.7907	0.0819	0.72596	1.3775
Small Further processor	0.3994	0.0819	0.36666	2.7273
Very Small Further processor	0.1330	0.0819	0.12212	8.1889
Renderer	0.4000	0.4468	0.22128	4.5192

B.4.2 Eligibility and Non-response Adjustment

The base weights associated with the short survey facilities were adjusted for non-response. Because 157 of the 173 non-responding facilities had an unknown eligibility status, it was assumed that they were distributed among eligible (respondent and non-respondent) and out-of-scope facilities in the same proportions as the respondents within each stratum. It was assumed that all non-respondents did receive their surveys. The non-response adjustment was applied in two steps. In the first step, the base weights of facilities were multiplied by the adjustment factor obtained by dividing the sum of the weights of all sample facilities by the sum of the weights of facilities with known eligibility status. Thus, the weight, w_{hi} for a facility i in stratum h, after the unknown eligibility adjustment can be written as follows:

$$
\begin{aligned}
w_{hi} &= (base\ weight)_{hi} \times (unknown_eligibility\ adjustment)_h \\
&= (base\ weight)_{hi} \times \left(\frac{S_1 + S_2 + S_3 + S_4}{S_1 + S_2 + S_3}\right)_h
\end{aligned}
$$

where S_1, S_2, S_3, and S_4 represent the sum of the weights for stratum h of eligible respondents, eligible non-respondents, unknown eligibility non-respondents, and ineligible facilities, respectively (see Table B-5). In the second step, the unknown eligibility adjusted

weight was further adjusted to account for eligible non-respondents, which was the final survey weight. As with the adjustment for unknown eligibility, the non-response adjustment factor was defined as the ratio of the sum of the weights of eligible facilities (both respondents and non-respondents) to the sum of the weights of the eligible respondent facilities only. This non-response adjustment was also performed within strata in order to account for differential response rates in the short survey. Table B-7 shows the non-response adjustment factors (both unknown eligibility adjustment and non-response adjustment for eligible non-respondents) and final weights for each stratum.

Table B-7. Non-Response Adjustment and Final Weight for the Short Survey

Stratum *h*	**Short survey base weight**	**Unknown Eligibility adjustment** $\left(\frac{S_1+S_2+S_3+S_4}{S_1+S_2+S_3}\right)$	**Non-response adjustment** $\left(\frac{S_1+S_2}{S_1}\right)$	**Short survey final weight** $(W_{h\,i})$
Large First Processor	1.9076	1.0101	1.0103	1.9467
Small First Processor	3.8191	1.0769	1.0099	4.1536
Large Further Processor	1.3775	1.0333	1.0000	1.4234
Small Further Processor	2.7273	1.1021	1.0141	3.0480
Very Small Further Processor	8.1889	1.1703	1.0161	9.7380
Renderer	4.5192	1.0541	1.0000	4.7635

EPA has revised the short survey weighting based on all responses received until December 31, 2002. These revised survey weights have been used to produce the national estimates. (See Section B.6.)

B.5 ESTIMATION METHOD

This section presents the general methodology and equations for calculating estimates from the short survey.

B.5.1 National Estimates

National total estimates were obtained for each characteristic and domain of interest by multiplying the reported value by the final survey weight (non-response-adjusted weight

including both unknown eligibility adjustment and adjustment for eligible non-respondents) and by summing all weighted values for the facilities that belong to the domain of interest *k*.

$$\hat{y}_k = \sum_i w_{ki} y_{ki}$$

Similarly, ratio estimates (for example, of the mean) in a given domain *k* were obtained as a ratio of two national total estimates. For example, the average cattle production by facilities doing first processing was calculated by dividing the weighted production of cattle by the weighted count of first processors.

$$\bar{y}_k = \frac{\sum_i w_{ki} y_{ki}}{\sum_i w_{ki}}$$

where w_{hi} is the final weight for facility *i*, y_{ki} is the cattle production for facility *i*, both in domain *k*, and the summation is over all facilities reporting cattle production.

Note that many facilities were involved in more than one type of activity or production. Their classification into one activity type, either first processing, further processing, rendering, or some combination was determined by the relative concentration of their production in any activity. Similar classification issues arose when reporting production by animal type (red meat, poultry, or mixed). For purposes of statistical weighting procedures, if at least 85 percent of total production was of a given type of activity, it was classified accordingly (e.g., first processor). If no activity type accounted for 85 percent of production it was classified as mixed type. The same rule was used for animal type.

B.5.2 Variance Estimates

To compute the correct estimates of standard errors a set of jackknife replicate weights was constructed and attached to each facility. Under the jackknife replication method, a number

of subsamples (called jackknife replicates) were generated from the full sample, and the entire weighting process as described in the previous sections was repeated for each replicate. In this way, a series of replicate weights were generated for each facility, which together with the full-sample weight were used to calculate sampling errors (see Wolters, 1985 for a description of the jackknife and other variance estimation methods)[3]. Given that there were almost 1,200 responding facilities for the short survey, it was decided to create 90 replicates for variance estimation. Each respondent was assigned a number between 1 and 90. The first replicate used the values from all facilities except those assigned to group 1. The other replicates were derived in a similar way by excluding the values for a different group each time.

In order to illustrate how the sampling errors have been calculated, let be the weighted national average estimate of a characteristic *y* (e.g., first processor meat production of cattle) for the entire data set. If is the corresponding estimate for jackknife replicate *r*, then the estimated variance of *y* is given by the following formula:

$$\mathrm{var}\left(\bar{y}\right) = \frac{89}{90}\sum_{r=1}^{90}\left(\bar{y}_{(r)} - \bar{y}\right)^2$$

where the summation extends over all 90 jackknife replicates that were formed for the short survey. This jackknife variance was often used to compute 95 percent confidence limits around the estimate. These limits are given by:

$$\bar{y} \pm 1.96\sqrt{\mathrm{var}\left(\bar{y}\right)}$$

The WesVar program was used to compute estimates of standard errors.

[3] Wolters, K. M. (1985) Introduction to Variance Estimation, Springer-Verlag Publishers, New York.

B.6 ANALYSIS OF THE DETAILED SURVEY

For the final rule, the base weight associated with a detailed sample facility was calculated by multiplying the reciprocal of the probability of including that facility in the first-phase sample of 2,000 facilities, by the reciprocal of the probability of including that facility in the detailed survey sample. Table B-8 shows the calculation of the base weight. The detailed survey base weight for a given first-phase stratum *h* and second-phase stratum *l* can formally be written as follows:

$$Base\ weight_{hl} = \left(\frac{n_h}{N_h}\right)^{-1}\left(\frac{m_l}{M_l}\right)^{-1}$$

where N_h is the number of facilities in the sample that belong to first-phase stratum h (N_h and n_h are shown in Table B-3), n_h is the number of facilities selected in the first-phase sample that belong to first-phase stratum h, M_l is the number of first-phase sample facilities that belong to second-phase stratum l, and m_l is the number of facilities selected in the detailed survey sample from second-phase stratum l (second-phase stratum totals can be found in the column labeled "Detailed Survey" in Table B-4).

Table B-8. Base Weight Calculation for the Detailed Survey Sample

Stratum	**First-phase inclusion probability** (n_n / N_h)	**Second-phase inclusion probabilities** (m_l / M_l)	**Detailed survey inclusion probabilities** $\left(\left(\frac{n_h}{N_h}\right)\left(\frac{m_l}{M_l}\right)\right)$	**Detailed survey base weights** $\left(\left(\frac{n_h}{N_h}\right)^{-1}\left(\frac{m_l}{M_l}\right)^{-1}\right)$
Large First Processor	0.8000	0.3447	0.2758	3.6260
Small First Processor	0.3996	0.3447	0.1378	7.2594
Large Further Processor	0.7907	0.0819	0.0647	15.4460
Small Further Processor	0.3994	0.0819	0.0327	30.5816
Very Small Further Processor	0.1330	0.0819	0.0109	91.8232
Renderer	0.4000	0.4468	0.1787	5.5952
Certainties	1.0000	1.0000	1.0000	1.0000

Due to duplication on the sample frame, a few facilities were sampled for both the short and detailed surveys. Such facilities were encouraged to complete both forms since estimates are made independently from both surveys.

The non-response adjustment for the detailed survey was carried out with the same methodology used to adjust the base weights for the short survey (see Section B.4.2). The non-response adjustments for each stratum are shown in Table B-9. However, the non-response-adjusted weights were further adjusted to benchmark them to the weighted counts of eligible facilities calculated from the short survey. This is because the much larger sample size in the short survey provides better estimates of the number of eligible facilities in each stratum. This second adjustment was done within type and size categories and yielded the final weight. If h designates a first-phase stratum, then the detailed survey final weight w_i for a given facility i can be written as
follows:

$$W_i = \left(NR - Adjusted\ Weight\right)_i \times \frac{\left(Estimated\ Number\ of\ Facilities\ from\ Short\ Survey\right)_h}{\left(Estimated\ Number\ of\ Facilities\ from\ Detailed\ Survey\right)_h}$$

Table B-9. Non-Response Adjustment and Final NR Adjusted Weight for the Detailed Survey

Stratum *h*	Detailed survey base weight	Non-response adjustment $\left(\frac{S_1 + S_2 + S_3 + S_4}{S_1 + S_2 + S_3}\right)$	Non-response adjustment $\left(\frac{S_1 + S_2}{S_1}\right)$	Detailed survey final NR adjusted weight (W_{hi})
Large First Processor	3.6260	1.0000	1.0000	3.6260
Small First Processor	7.2594	1.1731	1.0513	8.9525
Large Further Processor	15.4460	1.0000	1.0000	15.4460
Small Further Processor	30.5816	1.0577	1.2162	39.3391
Very Small Further Processor	91.8232	1.1818	1.2500	135.6479
Renderer	5.5952	1.0526	1.0000	5.8897

As a first step in the benchmarking, EPA categorized facilities into groups using the facility meat type (red meat, poultry, or a mixture) and production type (first processing, further processing, first processing/further processing, first processing/rendering, further processing/rendering, first processing/further processing/rendering). In addition, EPA gathered independent renderers into one group. As a result of crossing three meat types by six different production types and adding rendering as a separate type, EPA obtained the following 19 possible types of facilities.

1. Red Meat Slaughter,
2. Red Meat Slaughter/Render,
3. Red Meat Processor,
4. Red Meat Processor/Render,
5. Red Meat Both,
6. Red Meat Both/Render,
7. Poultry Slaughter,
8. Poultry Slaughter/Render,

9. Poultry Processor,
10. Poultry Processor/Render,
11. Poultry Both,
12. Poultry Both/Render,
13. Mixed Meat Slaughter,
14. Mixed Meat Slaughter/Render,
15. Mixed Meat Processor,
16. Mixed Meat Processor/Render,
17. Mixed Meat Both,
18. Mixed Meat Both/Render, and
19. Renderer Only.

EPA further split these facility types into non-small (or large) and small based on total production. Thus, EPA obtained a total of 38 possible groups of facilities. Within each of the 38 groups, EPA compared the estimated number of facilities using the short survey weights to the estimates using the detailed survey weights. Because the detailed questionnaire had data for only a few or no facilities within some groups, it was necessary to collapse some groups. Moreover, the adjustment factors were either too small or too large for some of the groups. Therefore, the 38 facility groups were collapsed to form 11 post-strata. To perform this step, EPA determined that it was appropriate to collapse certain production types and sizes within meat type. For example, two groups for non-small red meat slaughters and non-small red meat slaughter/render were collapsed into a single group. The criteria for collapsing were that the short survey sample count for the post-stratum (after collapsing) must be at least 10 and that for the detailed survey the sample count must be at least 5. Moreover, the adjustment factors must be between 0.4 (=1/2.5) and 2.5. The large variations in the post-stratification adjustment factors introduces large variations in the final (post-stratified) weights that results in increased variances. On the other hand, too much collapsing of cells would introduce bias. Therefore, the choice of lower and upper cut-off values for the adjustment factors was a trade-off between the bias and variance. EPA chose these lower and upper threshold values of adjustment factors because values larger

than 0.4 for lower threshold and values smaller than 2.5 for upper threshold would have resulted in too much collapsing, and hence the risk of potential bias. For the final rule, the certainty cases were held out of the post-stratification step, so that the sum of the weights for the non-certainty detailed survey respondents were made to match the sum of the weights for the non-certainty short survey respondents. As a result, none of the weights are now less than 1.0.

Within each of the 11 groups, we then benchmarked the detailed survey weights so that the national estimate of facilities using the detailed questionnaire database matched the national estimates based upon the short survey data. Because facilities from different sampling strata could be assigned to the same group, it is possible to have facilities with different survey weights within a particular group after collapsing. By collapsing these groups, we obtained information about facilities with similar characteristics, and improved precision for its national estimates based upon data available only from the detailed questionnaire (e.g., data about the wastewater treatment components).

Table B-10 provides the number of facilities in the short survey database, the number of facilities in the detailed questionnaire database, and the national estimate of the number of facilities. Both the short survey and detailed survey provide the same national estimate of number of facilities for each of the 11 post-strata.

Table B-10. Number of MPP Facilities

Post-Stratum	Number of Facilities		
	Shortsurvey Respondents	Detailed Survey Respondents	National Estimate
Non-small Red Meat Slaughter, Slaughter/Render, Processor, Processor/Render, Slaughter/Processor or Slaughter/Processor/Render	82	54	210
Small Red Meat Slaughter or Slaughter/Render	62	6	493
Small Red Meat Processor or Processor/Render	309	43	1873
Small Red Meat Slaughter/Processor or Slaughter/Processor/Render	122	16	1018

Table B-10. Number of MPP Facilities (Continued)

Post-Stratum	Number of Facilities		
	Shortsurvey Respondents	Detailed Survey Respondents	National Estimate
Small Mixed Meat	340	18	1911
Non-small Poultry Slaughter or Poultry Slaughter/Render	79	27	170
Non-small Poultry Slaughter/Processor, Processor, or Processor/Render	75	35	175
Non-small Poultry Slaughter/Processor/ Render	10	9	28
Small Poultry Slaughter, Slaughter/Render, Slaughter/Processor, Slaughter/Processor/Render, Processor, or Processor/Render	50	6	327
Render Only	29	20	132

Note the national estimates presented in Table B-10 include all MPP facilities (e.g., direct dischargers, indirect dischargers, zero dischargers, and all facilities regardless of size) and is not the same as the national estimate of number of regulated MPP facilities (e.g., direct dischargers above the category-specific production thresholds).
National estimates and corresponding standard errors for the detailed survey are calculated using the methods described in Section B.5 for the short survey.