Appendix A: Legal Authority for Diesel Fuel Sulfur Control

We are promulgating diesel sulfur controls pursuant to our authority under Section 211(c)(1) of the Clean Air Act. This section gives us the authority to "control or prohibit the manufacture, introduction into commerce, offering for sale, or sale" of any fuel or fuel additive (A) whose emission products, in the judgment of the Administrator, cause or contribute to air pollution "which may be reasonably anticipated to endanger the public health or welfare" or (B) whose emission products "will impair to a significant degree the performance of any emission control device or system which is in general use, or which the Administrator finds has been developed to a point where in a reasonable time it would be in general use" were the fuel control or prohibition adopted. The following sections describe current regulatory requirements that affect diesel sulfur content, and explain our bases for controlling diesel sulfur under Section 211(c)(1). This section contains a summary of the issues. Refer to the Preamble and RIA for more details.

A. EPA's Current Regulatory Requirements for Diesel

We currently have regulatory requirements for diesel fuel adopted under Sections 211(c) and 211(i) of the Act. Section 211(i)(1) prohibits the manufacture, sale, supply, offering for sale or supply, dispensing, transport, or introduction into commerce of motor vehicle diesel fuel which contains a concentration of sulfur in excess of 0.05 percent by weight, and which fails to meet a cetane index minimum of 40, or aromatics maximum of 35 percent beginning October 1, 1993. Section 211(i)(2) requires the Administrator to promulgate regulations to implement and enforce the requirements of section 211(i)(1), and authorizes the Administrator to require that diesel fuel not intended for motor vehicles be dyed in order to segregate that fuel from motor vehicle diesel fuel. See 40 CFR §80.29.

B. How the Proposed Diesel Sulfur Control Program Meets the CAA Section 211(c) Criteria

Under Section 211(c)(1), EPA may adopt a fuel control if at least one of the following two criteria is met: 1) the emission products of the fuel cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, or 2) the emission products of the fuel will significantly impair emissions control systems in general use or which would be in general use were the fuel control to be adopted. We are promulgating controls on sulfur levels in diesel fuel based on both of these criteria. Under the first criterion, we believe that emissions

products of sulfur in diesel fuel used in heavy-duty engines contribute to PM pollution. Under the second criterion, we believe that sulfur in diesel fuel will significantly impair the emissions control systems expected to be used in heavy-duty engines designed to meet proposed emissions standards. The following sections summarize our analysis of each criterion.

1. Health and Welfare Concerns of Air Pollution Caused by Sulfur in Diesel Fuel

We believe that the emission products of diesel sulfur contribute to air pollution that can reasonably be anticipated to endanger public health and welfare. Sulfur in diesel fuel leads directly to emissions of SO2 and sulfate PM from the exhaust of diesel vehicles. SO2 emissions from diesel engines are directly proportional to the amount of sulfur in the fuel. SO2 is oxidized in the atmosphere to SO3 which then combines with water to form sulfuric acid (H2SO4) and further combines with ammonium in the atmosphere to form ammonium sulfate aerosols. These aerosols are what is often referred to as sulfate PM. This sulfate PM comprises a significant portion of the "secondary" PM that does not come directly from the tailpipe, but is nevertheless formed in the atmosphere from exhaust pollutants. Exposure to secondary PM may be different from that of PM emitted directly from the exhaust, but the health concerns of secondary PM are just as severe as for directly emitted particulate matter, with the possible exception of the carcinogenicity concerns with diesel PM.

Approximately 1-2 percent of the sulfur in diesel fuel is not converted into SO2, but is instead further oxidized into SO3 which then forms sulfuric acid aerosols (sulfate PM) as it leaves the tailpipe. While only a small fraction of the overall sulfur is converted into sulfate emissions in the exhaust of diesel vehicles today, it nevertheless accounts for approximately 10 percent of the total PM emissions from diesel engines today. Furthermore, with the application of the exhaust emission control devices that will be necessary to meet either the PM or NOx emission standards in 2007, the conversion rate of sulfur in the fuel to sulfate PM in the exhaust increases dramatically. This sulfate PM is directly proportional to the sulfur concentration in the fuel. The health and welfare implications of the emissions of these compounds are discussed in greater detail in Section II of the Preamble and RIA.

Section 211(c)(2)(A) requires that, prior to adopting fuel controls based on a finding that the fuel's emission products contribute to air pollution that can reasonably be anticipated to endanger public health or welfare, EPA consider "all relevant medical and scientific evidence available, including consideration of other technologically or economically feasible means of achieving emission standards under [section 202 of the Act]." EPA's analysis of the medical and scientific evidence relating to the emissions impact of emissions from diesel vehicles which are affected by sulfur in diesel fuel is described in more detail in Sections II of the Preamble and RIA.

EPA has also satisfied the statutory requirement to consider "other technologically or economically feasible means of achieving emission standards under section [202 of the Act]." This provision has been interpreted as requiring consideration of establishing emissions standards under § 202 prior to establishing controls or prohibitions on fuels or fuel additives under § 211(c)(1)(A). See *Ethyl Corp. v. EPA*, 541 F.2d. 1, 31-32 (D.C. Cir. 1976). In *Ethyl*, the court stated that § 211(c)(2)(B) calls for good faith consideration of the evidence and options, not for mandatory deference to regulation under § 202 compared to fuel controls. *Id*. at 32, n.66.

In today's action, EPA is finalizing standards for fuels and vehicles together. Thus, it is first important to consider that the sulfur standards are not being promulgated as an alternative to emissions standards, but in addition to such standards, and as a necessary prerequisite to ensuring that heavy-duty engines can meet the engine standards. In addition, the heavy-duty emission standards being finalized today will begin with the 2007 model year, and even at that time, many older technology heavy-duty vehicles will still be on the road. Thus, another point to consider is that the emissions standards under § 202 will achieve smaller emissions benefits in the early years of the program and will not achieve their full emissions benefits for a number of years, while the sulfur standards will begin achieving some emissions benefits immediately through reducing emissions from the existing fleet of motor vehicles.

EPA has also considered more stringent emissions standards under § 202 as an alternative to regulating diesel sulfur. However, for the reasons described in Section III of the Preamble and RIA, the Agency concludes that the heavy-duty emission standards represent the levels of emission control that are economically and technologically feasible from heavy-duty engines and vehicles beginning in 2007. Moreover, EPA considered heavy-duty standards alone as an alternative to regulating diesel sulfur. However, as described in Preamble Section III, the Agency concludes that the heavy-duty standards would not be feasible without control of diesel sulfur. For these reasons, EPA finds that the alternatives of either more stringent engine and vehicle standards, or engine and vehicle standards without sulfur control, are not technologically or economically feasible options to regulating diesel sulfur.

EPA's consideration of other technologically and economically feasible means of achieving emissions standards under § 202 of the Act supports the conclusion that the diesel sulfur standards finalized today represent an appropriate exercise of the Agency's discretion under § 211(c)(1)(A), even when the heavy-duty engine and vehicle standards are considered.

2. Impact of Diesel Sulfur Emission Products on Emission Control Systems

EPA believes that sulfur in diesel fuel can significantly impair the emissions control technology of engines designed to meet the final emissions standards. We know that diesel sulfur has a negative impact on vehicle emission controls. This is not a new development. As

discussed in Section III of the Preamble to the final rule, aftertreatment technologies exist that we believe will be capable of achieving dramatic reductions in NOx and PM emissions from diesel engines for the 2007 model year. The aftertreatment technology for PM is already in an advanced state of development and being tested in diesel vehicle fleet demonstrations in the U.S. and Europe. The NOx adsorber aftertreatment technology, while already in commercial use in other applications is in a comparatively earlier state of development for use on diesel vehicles, but as discussed in Section III of the preamble and RIA, tremendous progress is already being made and EPA believes the lead time between now and 2007 will provide ample opportunity to bring this technology into the diesel vehicle marketplace. EPA believes that these PM and NOx aftertreatment technologies will be in general use on diesel vehicles by MY 2007, with the diesel sulfur controls adopted in this rule.

These aftertreatment technologies are ineffective in reducing NOx and PM emissions and incapable of being introduced widely into the marketplace at the diesel fuel sulfur concentrations typical today. Not only does their efficiency at reducing NOx and PM emissions fall off dramatically at elevated fuel sulfur concentrations, but vehicle driveability impacts and permanent damage to the aftertreatment systems are also possible.

In order to ensure passive regeneration of the diesel particulate filter as described in Section III of the Preamble and RIA, we are expecting that significant amounts of precious group metals (primarily platinum) will be used in their washcoat formulations. There are two primary mechanisms by which sulfur in diesel fuel can limit the effectiveness or robustness of diesel particulate filters which rely on an oxidizing catalyst function from platinum. The first is inhibition of the oxidation of NO to NO_2 and the second is the preferential oxidation of SO2 to SO3, resulting in production of sulfate particulate matter.

All of the NOx aftertreatment technologies discussed in Section III of the Preamble and RIA are expected to utilize platinum to oxidize NO to NO2 to improve the NOx reduction efficiency of the catalysts at low temperatures . In the case of the NOx absorber, conversion of NO to NO2 is also an essential part of the process of NOx storage. This reliance of NO2 as an integral part of the reduction process means that the functioning of the NOx aftertreatment technologies, like the PM aftertreatment technologies, will be significantly impaired by sulfur in diesel fuel.

3. Sulfur Levels that Exhaust Aftertreatment for Heavy-Duty Vehicles Can Tolerate

As discussed in Section III.F. of the Preamble, there are three key factors which when taken together lead us to believe that a diesel fuel sulfur cap of 15 ppm is necessary so that the NOx and PM aftertreatment technology on diesel engines will function properly and be able to meet the emission standards . These factors, as discussed in more detail in Section III of the

Preamble and RIA, are the implications of sulfur levels in excess of 15 ppm on the efficiency and reliability of the systems and their impact on the fuel economy of the vehicle.

The efficiency of emission control technologies at reducing harmful pollutants is directly impacted by sulfur in diesel fuel. Initial and long term conversion efficiencies for NOx, HC, CO and diesel PM emissions are significantly reduced by catalyst poisoning and catalyst inhibition due to sulfur. NOx conversion efficiencies with the NOx adsorber technology in particular are dramatically reduced in a very short time due to sulfur poisoning of the NOx storage bed. In addition total PM control efficiency is negatively impacted by the formation of sulfate PM. The formation of sulfate PM is likely to be in excess of the total PM standard proposed today, unless diesel fuel sulfur levels are no higher than 15 ppm. When sulfur is kept at these low levels, both PM and NOx aftertreatment devices are expected to operate at high levels of conversion efficiency, allowing compliance with the PM and NOx emissions standards.

The reliability of the emission control technologies to continue to function as required under all operating conditions for the life of the vehicle is also directly impacted by sulfur in diesel fuel. As discussed in Section III of the Preamble and RIA, sulfur in diesel fuel can prevent proper operation and regeneration of both NOx and PM control technologies leading to permanent loss in emission control effectiveness and even catastrophic failure of the systems. For example, if regeneration of a PM filter does not occur, catastrophic failure of the filter will occur. We believe, based on information available to us, that diesel fuel sulfur levels of 15 ppm are needed and would allow these technologies to operate properly throughout the life of the vehicle, including proper periodic or continuous regeneration .

The sulfur content of diesel fuel will also impact the fuel economy of vehicles equipped with NOx and PM aftertreatment technologies. As discussed in detail in Section III of the Preamble and RIA, NOx adsorbers are expected to consume diesel fuel in order to cleanse themselves of stored sulfates and maintain efficiency. The larger the amount of sulfur in diesel fuel, the greater this impact on fuel economy. Likewise PM trap regeneration is inhibited by sulfur in diesel fuel. This leads to increased PM loading in the diesel particulate filter, increased exhaust backpressure, and poorer fuel economy. Thus for both NOx and PM technologies the lower the fuel sulfur level the better the fuel economy of the vehicle.

As a result of these factors, we believe that it is appropriate to ensure that 15 ppm sulfur diesel fuel is available and are therefore capping in-use sulfur levels there.

4. Sulfur Sensitivity of Other Catalysts

Section 211(c)(2)(B) requires that, prior to adopting a fuel control based on a significant impairment to vehicle emissions control systems, EPA consider available scientific and economic data, including a cost benefit analysis comparing emissions control devices or systems

which are or will be in general use that require the proposed fuel control with such devices or systems which are or will be in general use that do not require the proposed fuel control. As described below, we conclude that the aftertreatment technology expected to be used to meet the final heavy-duty standards would be significantly impaired by operation on high sulfur diesel fuel. Our analysis of the available scientific and economic data can be found in the Preamble and RIA, including an analysis of the environmental benefits of the fuel control, an analysis of the costs and the technological feasibility of controlling sulfur to the levels finalized in the rule, and a cost effectiveness analysis of the final sulfur control and heavy-duty emissions standards. Under Section 211(c)(2)(B), EPA is also required to compare the costs and benefits of achieving the adopted vehicle emissions standards through emissions control systems that would not require the proposed control of sulfur , if any such systems are or will be in general use.

We have determined that there are not (and will not be in the foreseeable future) emission control devices available for general use on heavy-duty engines and vehicles that can meet the final heavy-duty emission standards and would not be significantly impaired by diesel fuel with high sulfur levels. NOx and PM emissions can not be reduced anywhere near the magnitude contemplated by the standards promulgated today without the application of aftertreatment technology. While some improvement may yet be possible in engine out emissions, these improvements will not allow the engines to meet the set of emission standards promulgated today. As discussed in Sections III and IV of the Preamble and RIA, there are a number of aftertreatment technologies that are currently being developed for both NOx and PM control with varying levels of effectiveness, sulfur sensitivity, and potential application to heavy-duty diesel vehicles.

As discussed in Sections III of the Preamble and RIA, all of the aftertreatmrent technologies that could be used to meet the PM or NOx standards are significantly impaired by the sulfur in diesel fuel. For PM control, EPA is not aware of a PM aftertreatment technology that is capable of meeting the PM standard adopted today and that would not need the level of sulfur control adopted in this rule. In addition, the NOx aftertreatment technologies evaluated by EPA all rely on the use of catalytic processes to increase the effectiveness of the device in reducing NOx emissions. For example both NOx adsorbers and compact SCR would rely on noble metals to oxidize NO to NO2, to increase NOx conversion efficiency at the lower exhaust temperatures found in diesel motor vehicle operation. This catalytic process, however, produces sulfate PM from the sulfur in the diesel fuel, and these NOx aftertreatment devices need the level of sulfur control adopted in this rule in order for the vehicle to comply with the PM standard.

For NOx control, both NOx adsorbers and compact SCR are significantly impaired by sulfur in diesel fuel, and both technologies would need very large reductions in sulfur from current levels to meet the NOx standard adopted today.

In addition, compact SCR is not a technology that would be generally available by the model year 2007 time frame. Significant and widespread changes to the fuel distribution system infrastructure would have to be made and in place by then, and there is no practical expectation that this would occur, with or without the low sulfur standard adopted today. While it is feasible and practical to expect that compact SCR may have a role in specific controlled circumstances, such as certain centrally fueled fleets, it is not realistic at this time to expect that the fuel distribution system infrastructure changes needed for widespread and general use of compact SCR on heavy-duty diesel vehicles will be in place by the model year 2007 time frame. In addition, even if SCR were used to obtain the emission performance required by today's standards, it is not clear that the vehicles would continue to maintain that level of performance in-use. SCR technology requires continued replacement of the urea supply on the vehicle by the vehicle operator. Failure to do so would make the SCR system completely ineffective. While various options to encourage vehicle operators to maintain their urea supply have been suggested (e.g., electronically monitoring urea injection and reducing engine power if not), none provide reasonable assurance, and often raise other serious concerns such as the safety of vehicle operation. Finally, EPA believes that the requirement of a cost benefit analysis under section 211(c)(2)(B) is not aimed at evaluating emissions control technologies that would require significant additional or different EPA fuel control regulations before the technology could be considered generally available.

In sum, EPA believes that both PM and NOx aftertreatment technologies require the level of sulfur control adopted today to meet the PM standards. There is no PM or NOx emissions control device or system that would be in general use that does not need this level of sulfur control for purposes of controlling PM. EPA also believes that NOx aftertreatment technologies either need the level of sulfur adopted today to be considered generally available for use to meet the NOx standard, or need sulfur controls approximating those adopted and even with such sulfur control would not be considered generally available for use to meet the NOx standard.

As described in Section III of the Preamble, EPA anticipates that all the diesel heavy-duty engine and vehicle technologies expected to be used to meet the final heavy-duty standards will require the use of low sulfur diesel fuel. If we do not control diesel sulfur to the finalized levels, we would not be able to set heavy-duty standards as stringent as those we are finalizing today. Moreover, vehicles already on the road would continue to emit at slightly higher levels than they would if operated on low sulfur fuel. Consequently, EPA concludes that the benefits that would be achieved through implementation of the vehicle and sulfur control programs cannot be achieved through the use of emission control technology that does not need the sulfur control adopted in this rule, and would be generally available to meet the emissions standards adopted in this rule .

This also means that if EPA were to adopt emissions control standards without controlling diesel sulfur content, the standards would be significantly less stringent than those finalized today based on what would be technologically feasible with current sulfur levels.

5. Effect of Diesel Sulfur Control on the Use of Other Fuels or Fuel Additives

Section 211(c)(2)(C) requires that, prior to prohibiting a fuel or fuel additive, EPA establish that such prohibition will not cause the use of another fuel or fuel additive "which will produce emissions which endanger the public health or welfare to the same or greater degree" than the prohibited fuel or additive. This finding is required by the Act only prior to prohibiting a fuel or additive, not prior to controlling a fuel or additive. Since EPA is not prohibiting sulfur in diesel fuel, but rather is controlling the levels of sulfur in diesel, this finding is not required prior to regulation. However, EPA does not believe that the finalized sulfur control will result in the use of any other fuel or additive that will produce emissions that will endanger public health or welfare to the same or greater degree as the emissions produced by diesel with uncontrolled sulfur levels.

Unlike in the case of unleaded gasoline in the past where lead served a primary function of providing the necessary octane for the vehicles to function properly, sulfur does not serve any useful function in diesel fuel. It is not added to diesel fuel, but comes naturally in the crude oil into which diesel fuel is processed. If it were not for the fact that it costs money to remove sulfur from diesel fuel, it would have been removed years ago to improve the maintenance and durability characteristics of diesel engines. EPA is unaware of any function of sulfur in diesel fuel that might have to be replaced once sulfur is removed, with the possible exception of lubricity characteristics of the fuel. As discussed in the Preamble, there is some evidence to suggest that as sulfur is removed from diesel fuel the natural lubricity characteristics of diesel fuel may be reduced. Depending on the crude oil and the manner in which desulfurization occurs some low sulfur diesel fuels can exhibit poor lubricity characteristics. To offset this concern lubricity additives are sometimes added to the diesel fuel. These additives, however, are already in common use today and EPA is unaware of any health hazards associated with the use of these additives in diesel fuel and would merely be used in larger fractions of the diesel fuel pool. We do not anticipate that their use would produce emissions which would reduce the large public health and welfare benefits that this rule would achieve.

EPA is unaware of any other additives that might be necessary to add to diesel fuel to offset the existence of sulfur in the fuel. EPA is also unaware of any additives that might need to be added to diesel fuel to offset any other changes to diesel fuel which might occur during the process of removing sulfur from diesel fuel.