In reference to Figure III.J-11, actual mining will begin at the upper end of Phase 1 with contour and "pre-stripping" cuts immediately adjacent to the two valley fill areas. All spoil from these initial operations will go to the valley fills to make space for spoil from future cuts to be placed on the mine bench. Excavator/truck or loader/truck spreads most commonly work at this stage, with limited dozing production adjacent to the valley fills. Some preliminary mining may take place in the area of the valley fill itself if coal seams are present and accessible for recovery.

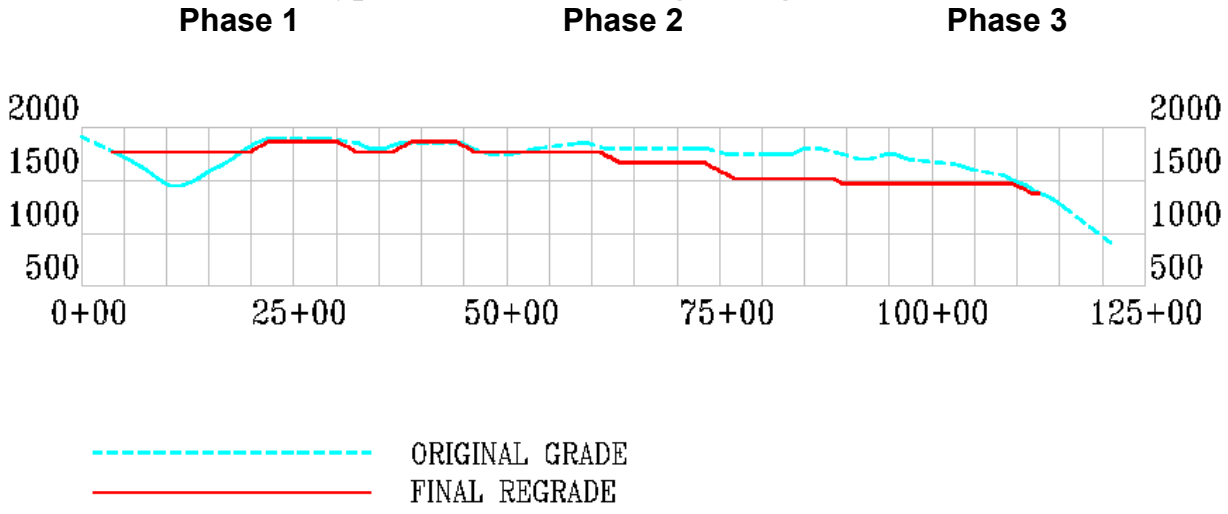
As development activities create the first cut benches in Phase 1, primary production will begin with larger equipment. A progression of cuts will then continue as described in Section III.I.2.b-c towards Phase 2, with development activities continuing in advance of the main production area. Much of the spoil from the ongoing Phase 1 development activities and bench cuts will still go to the valley fills to compensate for excess spoil generation in later areas of the mine.

At a point during Phase 3, a balance will be reached between excess spoil disposal and new spoil generation. By the midpoint of Phase 3, all of the spoil generation will be returned to the mine bench immediately adjacent to the advancing cuts. The latter cuts of Phase 3 are oriented perpendicular to the axis of the ridge to reflect that their spoil will remain on the bench. These cuts will have little overburden remaining after development activities, so their final spoil regrading elevations will be lower than those of the regraded benches in Phases 1 and 2. Thus, the reclamation grade surface will tend to step down from the start of mining to the end. The overall effect of this progressive diminishment of spoil volume and elevation is illustrated by the example MTR regrading profile shown by Figure III.J-12. Because of the movement of spoil to accommodate later stage production cuts, the reclamation elevations of a larger MTM/VF mine site may deviate significantly from the original ground profile and, therefore, may not qualify as AOC. This tends to be the case more on large sites or those with deep excavation of multiple seams than on small sites or those with shallow excavation of fewer seams.

c. Coal Production and Duration

Based on West Virginia permit data, a larger MTM/VF mine will produce approximately 10,000 tons of coal per acre under permit. Production rates can vary considerably over the life of a mine, but a typical mine will produce between 1,000,000 and 2,500,000 tons per year. Permitting of new reserves is ongoing in advance of active permits to maintain mine production at a relatively constant rate. Coal production during the development and primary production phases is chiefly by surface methods. Towards the latter stages of activities in a working area, secondary production by augering or highwall methods may be employed to maximize recovery, after which any remaining reserves in that area are considered to be inaccessible for future production. Secondary mining on true MTR sites (ones where the coal seam is mined from crop to crop in a 360 degree radius) can only occur in those areas that are not MTR.

Figure III.J-12
Typical MTR Mine Regrading Profile



Source: Meikle & Fincham, 1999

The life expectancy of mining in a given permit area varies proportionally to its size. Since MTM/VF mines are usually ongoing projects, the duration of mining on a site will be longer than the life of the individual mine permits covering the site. The typical larger MTM/VF mine site has a total life expectancy of around 10 to 15 years, and may involve a total lifetime production of between 10,000,000 and 40,000,000 tons. Smaller mines with MTM/VF characteristics do occur in single permitted areas with much shorter life expectancies, some lasting only one or two years in active production. Very large sites may allow mining to continue for 20 years or more.

d. Site Reclamation

This section deals primarily with the controls imposed on site reclamation and postmining land uses, and on the methods employed to achieve revegetation on regraded spoil.

d.1. Contemporaneous Reclamation

SMCRA does not have a specific limitation on the area that a mine operation can actively disturb, but does require that reclamation efforts, including backfilling, grading, topsoil replacement, and revegetation, occur as contemporaneously as practicable with mining operations. Larger MTM/VF operations may require large active disturbance areas to allow completion of valley fills, which may have to remain open for extended periods of time to allow completion of coal extraction at multiple bench/seam levels. Multiple working areas may also be necessary to allow efficient cycling of equipment between blasting and excavation areas. A typical larger MTM/VF mine site will have between 300 and 500 acres in active disturbance during its production phase. Reclamation activities follow progressively behind backfilling and regrading operations. Figure III.J-13 shows examples of progressive contemporaneous reclamation.

d.2. Topsoil Replacement/Substitution

Based on permit data, the majority of MTM/VF operations in West Virginia use topsoil substitution for reclamation. Use of topsoil substitutes is usually based on analysis of overburden samples to identify strata with acceptable grain textures to produce a growth substrate. These materials either end up on the surface during spoiling or are placed on reclamation surfaces by dozers following regrading. Mechanical breakdown of the overburden materials into a finer-grained growth substrate occurs during both excavation and regrading.

Both topsoil substitution and topsoil redistribution methods spread the soil materials at a typical thickness of about 4 to 12 inches-although experts in revegetation for reforestation recommend placement of topsoil and the top 10 feet of oxidized overburden/subsoils in a loose-dumped manner to promote rooting and exceptional tree productivity. Topsoil substitution will usually require application of lime and fertilizer, and topsoil redistribution may require these amendments for initially acidic or low-productivity soils. Lime and fertilizer addition rates maybe determined by laboratory testing of surface samples or applied at a constant rate established in the mine permit application. The typical fertilizer application rate is 600 pounds per acre of 10-20-10 or 10-20-20 NPK analysis fertilizer.

d.3. Revegetation Plan

Revegetation usually commences immediately following completion of topsoil or soil substitute spreading and preparation. Species mixes vary considerably depending on the intended postmining land use and the preferences of the coal company or surface owner. Forestland, commercial woodland, and fish and wildlife habitat land uses will be planted with woody species and seeded with herbaceous species, while hayland, rangeland, and postmining development land uses may receive only seeding.

Figure III.J-13
Examples of Progressive Contemporaneous Reclamation

Source: Meikle & Fincham, 1999

Mine reclamation plans typically have two categories of seed mixes: temporary and perennial. Temporary seed mixes are used for temporary stabilization of disturbed areas and stockpiles, and may be applied with the perennial seed mix for initial stabilization of reclamation areas before the permanent cover becomes established. The perennial seed mix may include some annual species, but overall, is intended to produce the permanent herbaceous cover for the reclamation site. Seed application rates vary between 30 and 110 pounds per acre depending on the species mix, but are normally about 75 pounds per acre. Seeding is usually conducted by a hydroseeder, using wood fiber mulch, applied at a rate of 1,000 pounds per acre. Broadcast methods and straw mulch may also be applied at 2,000 to 4,000 pounds (1 to 2 tons) per acre.

Woody species are planted by hand crews or mechanical planting machines prior to or concurrent with seeding activities. Species are typically planted in alternating row groups according to a planting plan map submitted with the mine permit application. Density of planting varies by species, but shrubs typically planted on 5 to 6 foot centers and trees on 8 to 10 foot centers. The total number of woody plants per acre is normally 600 to 700, intended to achieve a survivorship of approximately 450 woody plants per acre. Row planting does not generally produce uniform coverage, and open herbaceous areas are commonly interspersed in the completed site planting layout. The woody species black locust and lespedeza are also introduced by seeding, particularly on the faces of valley fills.

Tables III.J-1 and III.J-2 were developed from a review of twenty West Virginia mine permit applications and summarize the herbaceous (seeded) and woody (planted) species proposed by these applications. These are presented by common and scientific name, category (temporary or perennial for seeding and shrub or tree for planting), relative frequency of use (very common, common, or uncommon), and native status. Native status is interpreted from Reed (1988), Hitchcock (1971), and other sources. Where applied, the term “introduced” refers to species that are not originally native to the study area. It is noted that many of these introduced species have become naturalized to the study area from historic use in agricultural activities.

Table III.J-1
Typical MTM/VF Mine Reclamation Herbaceous Species

Species Name	Category		Application Frequency	*Native Status
	Temporary	Perennial		
Bermuda Grass (*Cynodon dactylon*)		X	U	introduced
Birdsfoot Trefoil *(Lotus corniculatus)*	X	X	V	introduced
Buckwheat (*Fagopyrum spp.*)		X	V	introduced
Clover, Ladino *(Trifolium spp.)*		X	U	introduced
Clover, Red *(Trifolium pratense)*		X	V	introduced
Clover, White *(Trifolium repens)*		X	C	introduced
Fescue, Tall (KY 31) *(Festuca spp.)*	X	X	V	introduced
Foxtail Millet *(Setaria italica)*	X	X	V	introduced
Lespedeza, Bicolor (Lespedeza bicolor)		X	V	introduced
Lespedeza, Kobe (Lespedeza bicolor var.)		X	C	introduced
Lespedeza, Sericea (Lespedeza cuneata)		X	U	introduced
Oats, Common *(Avena sativa)*	X		C	introduced
Orchard Grass *(Dactylis glomerata)*		X	V	introduced
Redtop *(Agrostis alba)*	X	X	C	introduced
Rye *(Secale spp.)*	X		C	introduced
Ryegrass, Annual *(Lolium spp.)*	X	X	V	introduced
Ryegrass, Perennial *(Lolium perenne)*	X	X	V	introduced
Smooth Bromegrass *(Bromus spp.)*	X		U	introduced
Timothy *(Phleum pratense)*		X	U	introduced
Weeping Lovegrass *(Eragrostis curvula)*		X	U	introduced
Winter Wheat *(Triticum spp.)*	X	X	C	introduced
Yellow Sweet Clover *(Melilotus officinalis)*	X	X	C	introduced

V - very common, C - common, U - uncommon
*Reed (1988), Hitchcock (1971)

Table III.J-2
Typical MTM/VF Mine Reclamation Woody Species

Species Name	Category		Application Frequency	*Native Status
	Shrub	Tree		
Autumn Olive (*Elaeagnus umbellata*)	X		U	introduced
Bigtooth Aspen *(Populus grandidentata)*		X	C	native
Black (European) Alder *(Alnus glutinosa)*		X	V	introduced
Black Locust *(Robinia pseudoacacia.)*		X	C	native
Black Oak *(Quercus velutina)*		X	U	native
Black Walnut *(Juglans nigra)*		X	U	native
Chestnut Oak *(Quercus coccinea)*		X	U	native
Chinkapin Oak *(Quercus muhlenbergii)*		X	U	native
Crabapple *(Malus spp.)*	X		V	hybrid
Gray Dogwood *(Cornus spp.)*	X		V	native
Hybrid Poplar *(Populus spp.)*		X	U	hybrid
Japanese Barberry *(Berberis thunbergii)*	X		C	introduced
Pitch Pine *(Pinus rigida)*		X	U	native
Red Maple *(Acer rubrum)*		X	U	native
Red Oak *(Quercus rubra)*		X	U	native
Scotch Pine *(Pinus sylvestris)*		X	C	introduced
Sugar Maple *(Acer saccharum)*		X	U	native
Sumacs *(Rhus spp.)*	X		C	native
Sweet Gum *(Liquidambar styraciflua)*		X	U	native
Virginia Pine *(Pinus virginiana)*		X	C	native
Washington Hawthorn *(Crataegus phaenopyrum)*	X		V	native
White Ash *(Fraxinus americana.)*		X	U	native
White Oak (*Quercus alba*)		X	U	native
White Pine (*Pinus strobus*)		X	C	native
Yellow Poplar *(Liriodendron tulipifera)*		X	V	native

V - very common, C - common, U - uncommon
*Reed (1988), Hitchcock (1971)

K. EXCESS SPOIL DISPOSAL

Excess spoil disposal is a common component of surface mining operations occurring on steep-sloped coal mining sites. Several options are available for disposing of excess spoil, including the valley fills that are the focus of this EIS. Excess spoil may also be disposed of on adjacent pre-SMCRA mining benches, and on adjacent active mine permits and abandoned mine land reclamation projects.

Valley fills offer a means of disposing of excess spoil in the immediate vicinity of its point of generation. The costs of truck haulage of spoil are directly related to haul distance, and from an economic standpoint it is desirable to locate spoil disposal sites as close to the production areas as possible. The impractical alternative would be haulage to a disposal location on another mountaintop or ridge crest. These sites are not available within reasonable haul distances because of topographic or property ownership constraints, and backstacking on undisturbed sites would significantly elevate the land surface and might bury other unrealized coal reserves. Secondary reasons for valley fills relate to equipment operation and postmining land use goals. For production and cost optimization, mining cuts may cross intervening hollows to advance through more than one ridge line at a time, eventually forming a single advancing highwall as the ridge lines merge at the head of the hollow. Movement of equipment between the individual ridge line cuts is greatly facilitated by having the valley fills in place as a travel surface. This is particularly true for walking draglines, which move at a rate of about one mile per day. Equipment relocation would be significantly delayed by less direct routes around the headwaters of a hollow. If agriculture, residential, industrial, or commercial postmining land uses are proposed, it is also desirable to use valley fills to aid in creating the greatest area of usable level ground.

Filling of valleys results in the loss of ephemeral, intermittent and in some cases perennial stream reaches along with their associated aquatic habitats. Toe-of-fill sediment ponds, although normally temporary, also change the habitat and profile of stream valleys beyond the fill itself. Valley fills significantly change the headwater topography of affected streams and can alter surface water runoff and groundwater recharge and discharge patterns. There is also concern regarding long-term fill stability. This section summarizes the principles behind excess spoil generation and disposal practices, and discusses their related hydrologic impacts, stability, and trends in excess spoil generation within the study area.

1. Characteristics of Excess Spoil Generation and Valley Fills

Head-of-hollow fill, valley fill, and durable rock fill are terms used by OSM regulations to describe excess spoil fills placed in steep sloped mining areas [see 30 CFR 816/817.71-74 performance standards; 30 CFR 701.5 definitions, and 30 CFR 780.35 permitting rules]. The common factors between the terms head-of-hollow and valley fill are that the side slopes of the existing hollow or valley measured at its deepest point are greater than 20 degrees, or that the average slope of the profile of the hollow or valley from the toe of the fill to the top of the fill is greater than 10 degrees. A head-of-hollow fill is simply a fill occurring in the uppermost reaches of a hollow, whereas a valley fill is essentially any fill occurring in a hollow or valley downstream of its headwaters. Head-of-hollow fills less than 250,000 cubic yards are required to set the top of the fill level with the coal seam to be mined. Head-of-hollow fills larger than 250,000 cubic yards must set the top of the fill at or near the level of the adjacent ridge line.

Head-of-hollow and valley fills must be constructed in lifts of spoil no greater than four feet in thickness. The face of the fill is thus constructed in stages with a 50% slope and 20-foot terraces at 50-foot intervals. Surface drainage control is provided by a rock core chimney drain for the head-of-hollow fill and by diversions at the junction of the fill and natural ground for valley fills. The terrace surfaces may slope into the fill face at a slope of approximately 1 percent, and towards the center of the fill face at a 3 to 5 percent slope. In these cases, surface runoff from the terraces and fill face may be carried to the toe of the fill by a central rock-lined channel, and from surrounding slopes draining to the fill by side channels known as diversions or *groin ditches*. In other cases, the fill crest and terrace surface may slope towards the sides and discharge via the groin ditches. Both fill types also require installation of sub-drains prior to lift placement in order to control seepage (springs or seeps) and any internal drainage resulting from infiltration of rainfall into the fill mass. An underdrain is typically a sizable ditch, first lined with geotextile or filter fabric, and then filled with graded rock. The filter fabric is then overlapped on top of the rock-filled trench to assure water, but not dirt, silt, or sediment fines, can get into the drain. Underdrains assure desirable low levels of water within the fill and increase stability. These techniques are standard geotechnical practices to assure stability and erosion controls. All excess spoil fills must achieve a factor of safety against mass movement of 1.5.

The head-of-hollow and valley fill method of fill construction was developed to some degree prior to the passage of SMCRA in the mid- to late-1960's because of waste rock disposal practices utilized in Interstate highway construction in West Virginia, and continued throughout the 1970's. Prior to SMCRA passage, controlled excess spoil disposal was not practiced in Virginia, and overburden excavated by mining was typically place/dumped indiscriminately on the out slope below the mining bench. In Kentucky, pre-SMCRA excess spoil fills were typified by a technique of dumping (similar to durable rock fill construction described below, but without the classification of spoil as durable) and subsequent regrading of "angle of repose" excess spoil to a more stable slope. The face of these fills were then benched or terraced. Figure III.K.1-1 shows a typical completed section of a valley fill toe and face parallel to the valley profile. Center drains are typically only used in West Virginia, with groin drains being used in the other states of the study area. Figure III.K.1-2 provides a photograph of these drainage features showing both center drains and groin drains.

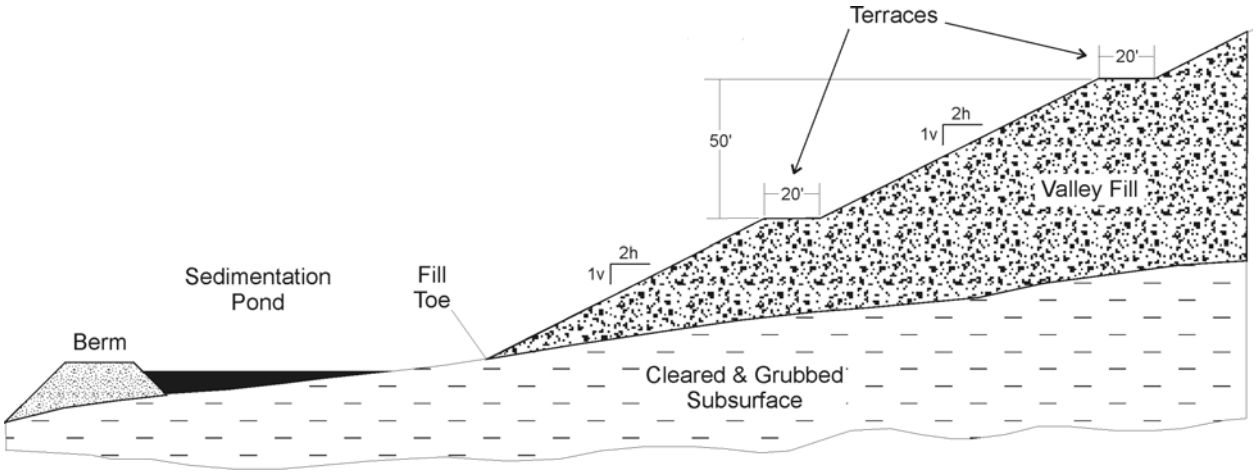
In the late 1970's and early 1980's the durable rock fill method became the predominant excess spoil disposal technique due to the cost efficiencies of the technique. Durable rock fills are the most commonly-constructed type of valley fills and advance from the head of a valley downstream by gravity segregation of dumped *durable* overburden. Durable overburden is classified as consisting of at least 80 percent *durable rock* on a unit volume basis, or rock that can pass certain strength and weathering tests, such as a slake durability test. Durable rock fill construction creates a free face of end-dumped spoil at the angle of repose--which is subsequently regraded when the limits of disposal are reached. The EIS Fill Stability Study [see Appendix H] recorded lifts of existing fills to range between 30 to over 400 feet in thickness. Regrading results in a 2 horizontal to 1 vertical slope ratio with terraces every fifty feet. Surface drainage control is established with the same diversion and groin ditches (100-year storm capacity) as head-of-hollow and valley fills, except West Virginia has a unique state program provision to create a single rock chimney drain to handle all runoff above and on the fill. Internal drainage is assured by the formation of a thick rock blanket drain during end dumping. Figures III.1-3 and III.1-4 show a construction sequence and representative photographs of durable rock fills, respectively.

a. Swell Factor and Excess Spoil Generation

The primary reason for using valley fills is that excavation of overburden results in a greater volume of material than was present on the mine site before mining. When bedrock is broken up forming spoil, void spaces are left between the individual rock fragments, causing them to occupy a greater volume than the original, unbroken rock. This expansion is referred to as *swell* and typically represents a volume increase of about 40 percent. Compaction of spoil during backfilling partially offsets swell as the rock fragments are squeezed together by the weight of overlying material, but this *shrinkage factor* will not completely return the spoil to its solid, or *bank*, volume. The net difference between swell and shrinkage is known as the *bulking factor* of the overburden, which is about 25 to 40 percent for sandstone and 15 to 25 percent for shale (Miekle & Fincham, 1999). Bulking factors vary from mine site to mine site depending on the overburden geology, but the industry average is about 25 percent. In other words, 100 cubic yards of overburden will typically generate about 125 cubic yards of backfilled spoil. Within the mining industry, the term *swell factor* is commonly used in place of the engineering term bulking factor, and will also be used herein. These concepts are illustrated by Figures III.K.1-5 and III.K.1-6.

Particularly on steep-sloped mine sites, the excess spoil generated by the swell factor cannot be completely backfilled on the mine bench without construction of potentially unstable slopes or substantial deviation from AOC. The maximum amount of spoil that can be returned to the mine bench is constrained by SMCRA slope stability and design requirements (i.e, the slope at which backfills can be constructed), perimeter areas occupied by erosion and sediment control structures, as well as access roads.

Figure III.K-1
Typical Profile Section of a Valley Fill Toe

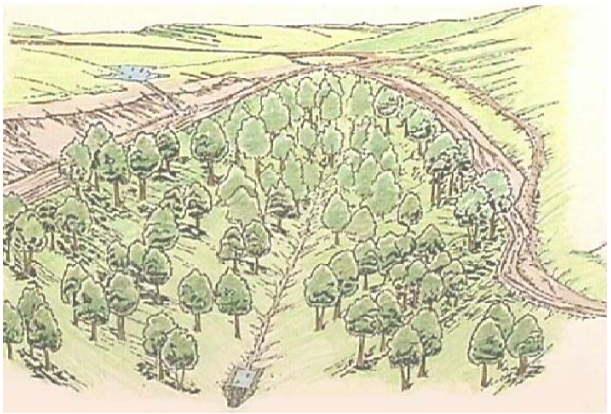


Source: Meikle & Fincham, 1999

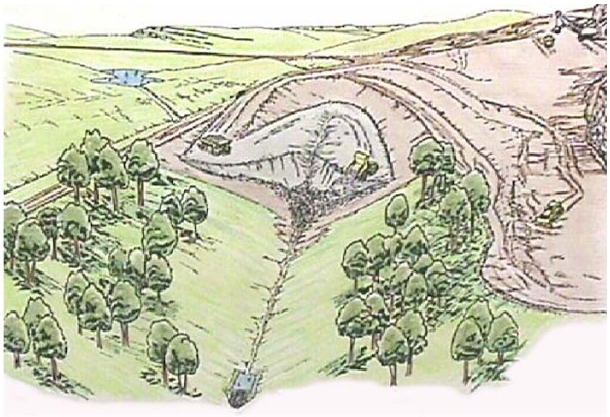
Figure III.K-2
View of Typical Center Drains and Groin Ditches

Source: McDaniel & Kitts, 1999

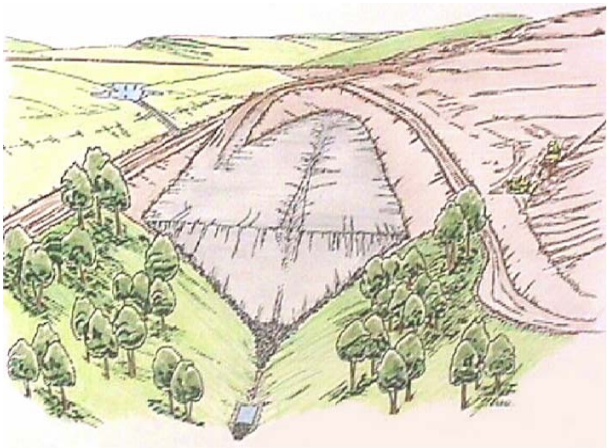
Figure III.K-3
Center Drain Durable Rock Valley Fill Construction Sequence



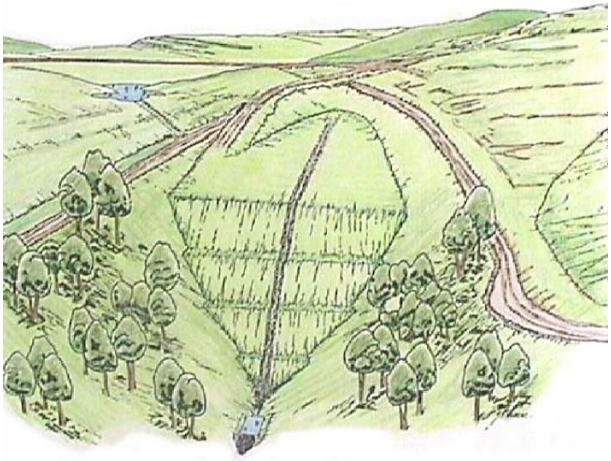
(1) Sediment Pond Construction



(2) Fill Placement



(3) Completed Fill Placement



(4) Completed Regrading/Revegetation

Source: Arch Coal, Inc., 1999

Figure III.K-4
Durable Rock Valley Fill Photographs

(1) Valley Fill Construction

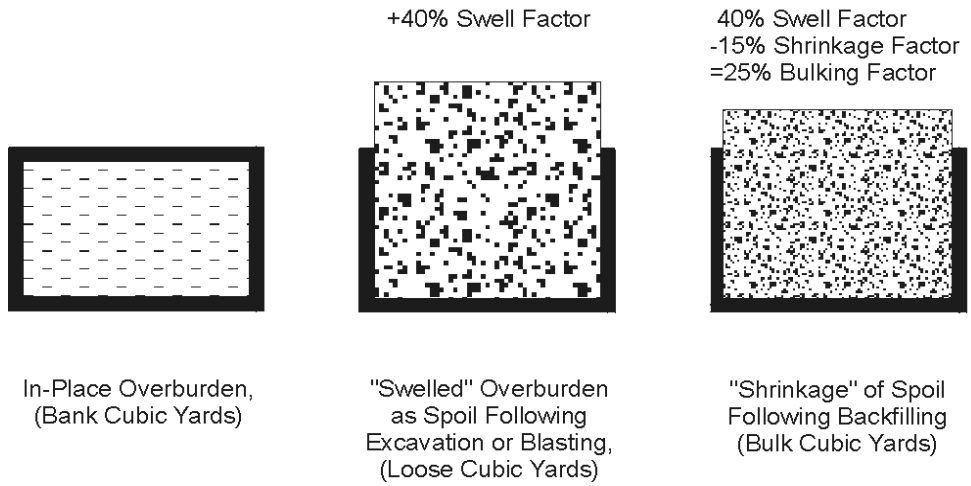
(2) Close-up of End-dump Fill

(3) Completed Regrading

(4) Completed Revegetation

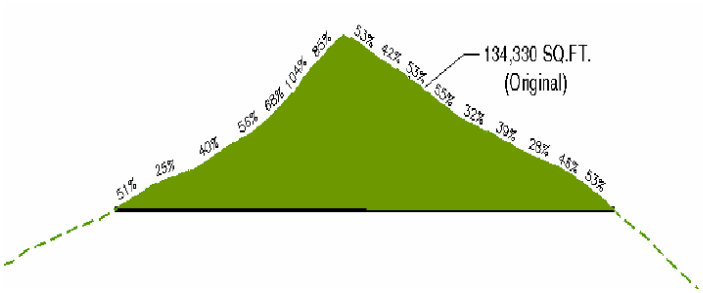
Source: Arch Coal, Inc., 1999

Figure III.K-5
Example of Swell, Shrinkage, and Bulking Factors in Overburden Excavation and Spoil Backfilling

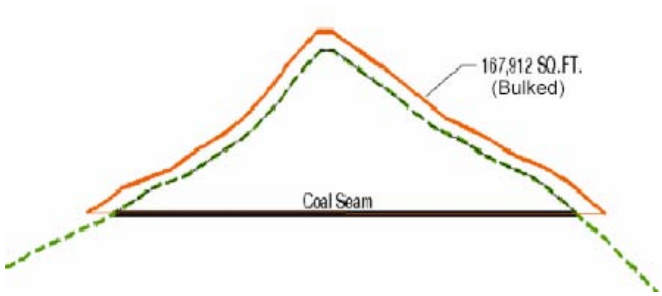


Source: USOSM AOC Presentation

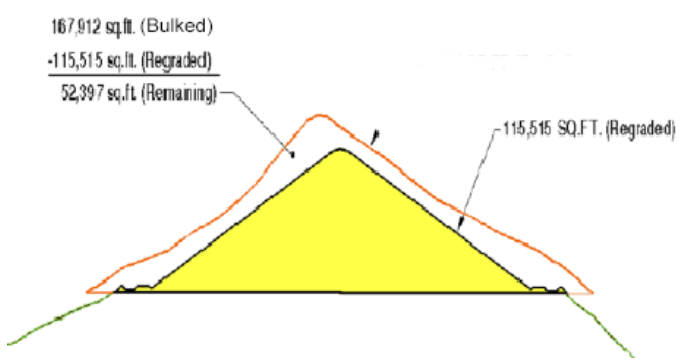
Figure III.K-6
Example of Excess Spoil Generation on a Steep-Slope Mine Site



(1) In-Place or "Bank" Cross Section



(2) Bulked Cross Section



(3) Backfilled Cross Section Showing Excess Spoil

Source: Arch Coal, Inc., 1999

b. Relationship of Valley Fill Construction Technique and Water Quality

Valley fills are required to be constructed from non-toxic spoil materials; therefore, sedimentation is the typical consideration for water quality during their construction rather than chemical impacts. Fills built using the conventional lift-construction method have an advantage for sedimentation control in that they are contemporaneously completed, topsoiled, and revegetated from the toe up as construction progresses. This results in significantly less disturbance upstream of the sediment pond, and requires less frequent cleaning of the pond. Some durable rock fills use a hybrid approach for sediment control by placing several initial lifts at the fill toe location, then end-dumping material progressively toward the toe. This creates a temporary sediment trapping area behind the initial lifts and reduces sediment loading to the downstream sedimentation pond. Sedimentation impacts are primarily a concern for the stream reach between the fill toe and the sedimentation pond, if the pond is not located directly below the fill toe. When a central chimney drain is constructed for the head-of-hollow fill using large boulders, a sixteen-foot wide porous conduit in the center of the fill is created. This chimney core is an excellent sediment trap thus reducing sediment loading to the downstream pond.

c. Valley Fill Stability

There has been anecdotal evidence that valley-fill instability (landslides or land slips on fills) are neither commonplace nor widespread; and, that properly constructed valley fills are well-engineered and stable structures.

The EIS Steering Committee chartered a study of fill stability to corroborate anecdotal perception with empirical information. The complete report is included in Appendix H and is presented on the mountaintop mining website, web address (www.epa.gov/region3/mtntop).

The fill stability investigation evaluated the effectiveness of SMCRA-based regulations through the use of geotechnical indicators of fill stability in the permitting process and in the field. The scope of the study included the identification and analysis of past and existing cases of instability in valley fills in Appalachia. It also included the collection and analysis of indicator data from approximately 120 fills relating to fill designs, present-day construction practices, and the existing conditions of as-built embankments. The fill stability investigation evaluated the current state and federal regulations, policies, and practices; government documents that identify and discuss issues related to the objective of fill stability; and pertinent geotechnical literature. The procedures undertaken by OSM included: (1) discussions with state/federal inspection-and-enforcement (I & E) and permit-review personnel and federal geotechnical experts; (2) review of permits, inspection reports, and other relevant documentation; and (3) aerial and ground-level site inspections.

For the purposes of this study, a fill instability is defined as any evidence that: (1) part of the fill's mass has separated from the rest of the fill; (2) the separation occurs along a continuous slip surface, or continuous sequence of slip surfaces, intersecting the fill's surface; and (3) some vertical displacement has occurred. The instabilities, or "slope movements," identified with these criteria have been further distinguished between critical and non-critical. Critical slope movements are those judged to occur over a large fraction of the fill face (e.g. over at least a few outslope benches) and/or require a major remediation effort (redistribution of the spoil from one part of the fill to another, construction of rock-toe buttresses, extensive reworking or augmenting of the drainage

systems etc.). Non-critical cases of instability are those covering a small area on the fill (e.g. not more than one bench on the fill face) and only necessitating minor reworking of the fill material (i.e. without significantly changing the fill's original configuration).

The word "instability" is a general term used in the field of engineering when an engineered construction material or structure fails to remain intact (e.g., without deforming, cracking, or breaking) under stress. For valley fills, commonly used terms descriptive of instabilities include landslide and slip. These types of slope movement are distinguished according to distance and rapidity of material transport. The more dangerous of these is the landslide, which involves sudden, rapid, and relatively distant movement of material. A slip has many features that are similar to a landslide but is characterized by a gradual movement over a shorter distance. Although this type of movement is at first less of a safety hazard compared to a landslide, it can turn into a slide if left unremediated. Both landslides and slips can be considered critical slope movements if they are large enough and costly to remediate. Relatively small events, i.e. non-critical instabilities, are simple to repair. However, if left unattended to, they can become critical.

Although most valley fills occur in relatively remote areas, some of them are above or adjacent to buildings (primarily residential) and public roads. Structures at these locations risk severe damage, if not total destruction, if the fill is not stable. People in or on these structures during a landslide may experience injury.

It is important to note that the danger posed by fill instability is limited in areal extent. Those people or structures on or very close to an unstable fill can be affected. However, catastrophic impacts over a great distance down-valley of a fill instability, as occurred during the Buffalo Creek coal waste dam failure, should not occur. Slope movement on a valley fill would not be expected to impact distant areas because:

- Fill designs build in a substantial, long-term factor of safety against instability and have specific drainage control measures.

- No large quantity of water should be present in properly designed valley fills to "lubricate" the fill material into a flowing mass that could transport for any great distance. The regulations prohibit ponds on fills or fills impounding water behind them. Even improperly-designed fills should have minimal impounding potential.

- Dam failures may release large volumes of water with little or no warning. Fill embankment failures can also be sudden, but are often characterized by the presence of warning signs of instability (cracks, increased seepage, etc.) and a slow creep.

Proper design of stable excess-spoil fill structures is dependent upon accurate characterization of rock strength and durability (30 CFR §816.73). Excess spoil consists of overburden or interburden (soil and rock excavated during the mining operation) not needed to reclaim the disturbed area to the approximate original contour of the land. The excess spoil material forming the rock fill is generally made up of angular blast rock. Before the enactment of SMCRA, excess spoil disposal structures were generally constructed with minimal engineering guidance. Often these structures were placed at locations selected strictly to optimize the mining operation. Since the passage of SMCRA, regulations require increased engineering effort directed toward design and construction

of excess spoil disposal areas to improve safety. The fill stability study found only a very small percentage of excess spoil fills that experienced instability over the past 18 years.

2. Trends in Valley Fills

To determine the actual extent of valley fills within the EIS study area, the EIS Steering Committee commissioned a Fill Inventory. The inventory is to develop an accurate, Geographic Information System (GIS)-based database of valley fills constructed or proposed for construction in mining permits. A GIS is queried like any computerized relational database to show statistics about the information in the database, such as valley fill size, numbers, date of construction, etc. As such, the inventory was used to illustrate impacts within the EIS study. The fill data for the inventory were gathered by the states of Kentucky, Virginia, and West Virginia under special efforts funded by OSM and EPA, and gathered by OSM for Tennessee. The inventory was obtained from maps and databases maintained by each of the regulatory authorities. The specific metrics from this study were as follows for each state:

Total number of fills
- Approved each of the years, 1985 through 2001, and cumulatively.
- Fills constructed.

Area of fill "footprint," i.e., fill extent, or acres of ground covered by fill
- Total acreage for the years 1985 through 2001, and by year of permit issuance.
- Range of individual fill footprint sizes for the years 1985 through 2001, and by year of permit issuance.
- Average of individual fill footprint sizes for the years 1985 through 2001, and by year of permit issuance.

Watershed size, or the acres of land upstream, or upslope, of the fill, i.e., between the fill and the ridgetops within each valley
- Total watershed acreage for all fills for the years 1985 through 2001, and by year of permit issuance.
- Average watershed size for each fill for the years 1985 through 2001, and by year of permit issuance.

Miles of stream under fill footprints
- Total miles of 30-acre watershed stream net affected 1985 through 2001, and by year of permit issuance.

The following data were assembled as a part of the inventory effort:
- digital maps of the footprints of the fills,
- acreage of the footprints of the fills,
- volume of fill, if available,
- length of streams covered by footprints of the fills,
- size of the watershed (measured from the toe of the fills),
- permit numbers,
- permit status,
- fill identification numbers,
- current status of each fill (constructed or not), and
- original permit issue dates for each fill.

The scope of the inventory was originally established for fills permitted between January 1, 1982, and December 31, 1999. The initiation date was intended to approximate the dates on which the Secretary of the Interior approved the permanent programs under SMCRA for the states in the study area. The permanent programs went into effect on the following dates: West Virginia on January 21, 1981; Virginia on December 15, 1981; and Kentucky on May 18, 1982. After administering its approved permanent program, Tennessee relinquished its program and a Federal program was implemented on October 1, 1984. Upon approval of a permanent SMCRA program in a state, all existing mining operations had to obtain a new, permanent program permit in order to continue operations. Data from the years immediately following approval of a permanent program in a state show a high level of permitting activity representing this "repermitting" requirement rather than useful information on the trends of permitting new mines. Therefore, the beginning date of June 1, 1985, was established. The ending date has changed to provide more current data for the inventory. As a consequence, the analysis in this section of the EIS will be mostly for the period from January 1, 1985, through December 31, 2001, so as to present valid trend information. There have been several changes in the inventory since the original version was first completed in 1999. First, the inventory now contains data for the years 1999, 2000, and 2001. Second, the additional time has allowed for additional review of the data and several changes have been made because of errors in the original inventory, discovery of fills that were not originally included, and changes in the status of fills and the permits under which they were approved. These changes are minor but they may be confusing to those who received copies of the original inventory report.

An industry practice is to permit more surface area for disturbance than is likely to be affected by the operations planned. This allows the mining operation to respond more quickly to changing market conditions. The rationale is that it's simpler to amend permits to reduce the affected area than it is to increase the affected area. Because of this practice, comparisons are made of the number of fills constructed to the number of fills approved or permitted. For permits where the entire bond has either been released to the permittee (because the site has been fully reclaimed) or has been forfeited (so the site can be reclaimed by the regulatory authority), the number of fills that will be constructed on that permit area is definite because the mining operation is complete. For all other permits, the fills permitted are either constructed or may be constructed because the mining operation is not complete. The reader should note that the proportion of completed fills on newer permits will be significantly less than those on older operations. This is primarily due to the fact that these newer fills just simply have not been built because mining operations have not progressed to the point where they are needed. Also, construction of fills approved prior to 1995 was verified using satellite images, while verification of fills approved after 1995 has been done using data bases that may or may not be updated in the most expeditious manner.

Another common practice is to repermit surface coal mining and reclamation operations using the same facilities, such as valley fills. This happens for a number of reasons including changes in ownership, sale of mining companies, closure and reopening of operations based on market conditions, etc. This practice results in a high number of valley fills being identified under two or more permit numbers. Since the purpose of this inventory was to develop an accurate count of valley fills that actually exist, and not just a listing of valley fills approved under all permits, this practice of repermitting had to be considered. Also, the inventory was to allow its users to have a sense of how valley fills have been approved by the various permitting agencies over time. To account for this, each valley fill was only counted the very first time it was permitted. If the same facility was repermitted, it retained the permit number and issue date of the original permit. Most

state regulatory agencies and OSM maintain inventories and data bases of valley fills approved by permits. Since this results in each valley fill being included every time it is repermitted, these inventories will seldom correspond on a one to one basis with the inventory presented in this report.

This inventory was an attempt to identify fill structures placed in valleys or heads-of-hollows. It includes fills approved or constructed on all surface coal mining and reclamation operations including mountaintop removal operations, contour and auger mining operations, underground mine face ups, processing and loading facilities, preparation plants, roads, or any other facility that had to make use of a spoil or refuse disposal site in order to operate. No distinction was made between spoil or refuse fills. Impoundments were added whenever such information was made available. This was done in order to provide as complete an inventory as possible and to accurately reflect field conditions. The majority of the fills are permitted as part of surface mining operations. Of the 6697 fills counted in this inventory, 5688 (85 percent) are on surface mining operations, 719 (11 percent) are on underground mining operations, and the remaining 290 (4 percent) are on other types of operations such as preparation plants, tipples and load-outs, or other types of facilities. It is assumed that all the files on surface mining operations and most of the fills on underground operations are spoil fills. If is certain that a fair percentage of the fill structures on some underground mines and most of the other types of operations are refuse fills or impoundments.

The data for the inventory are fairly complete and allow for meaningful analysis of trends. Reliable information on the permitted fill volume is generally not available except in the individual permitting documents, and was not analyzed. Stream measurements were estimated from a stream network derived using a flow accumulation model over the National Elevation Data set (NHD), and based on draining a minimum watershed size of 30 acres. The digital "hydrography layer" of a USGS 7.5-minute topographic map consists of two line types--a solid blue line (representing perennial stream segments) and a broken blue line (representing intermittent stream segments). Delineation of the two stream types on USGS 7.5-minute topographic map was highly subjective, and followed no standard qualifying criteria. The synthetic stream net is objective and remains more consistent across State boundaries than the anecdotal evidence of a USGS 7.5-minute topographic map. Measurements for ephemeral stream segments were not available and are not included in this section. The inventory has been developed in GIS using ArcView as the base program for mapping and data analysis. OSM is looking into the feasibility of making the map coverages and data used for this analysis available on its web page located at http://www.osmre.gov.

The following figures show the extent of the entire study area and provide a visual indication as to the level of valley fill construction in the states within the study area.

Figure III.K-7: Overview of the Valley Fill Inventory Study Area

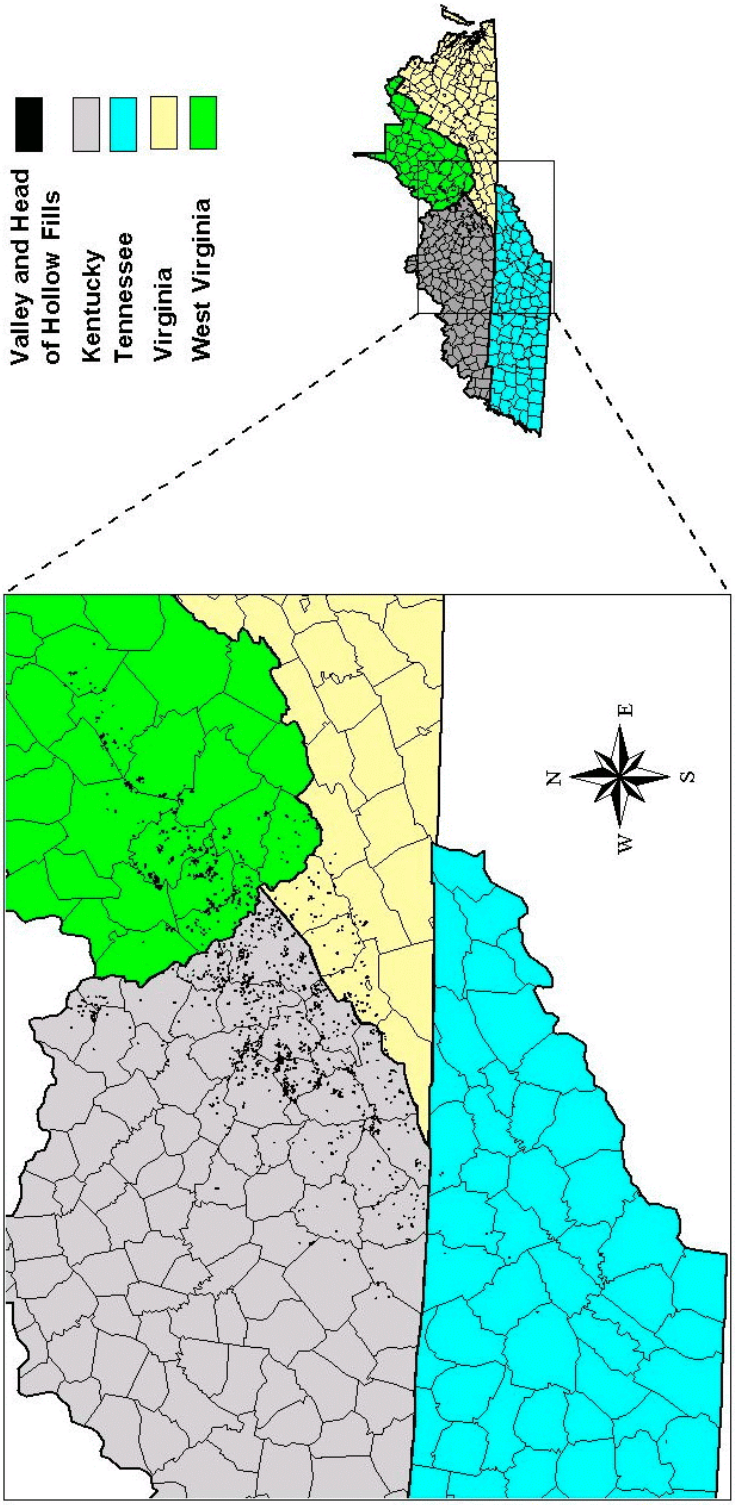


Figure III.K-8: Kentucky Fill Inventory Study Area

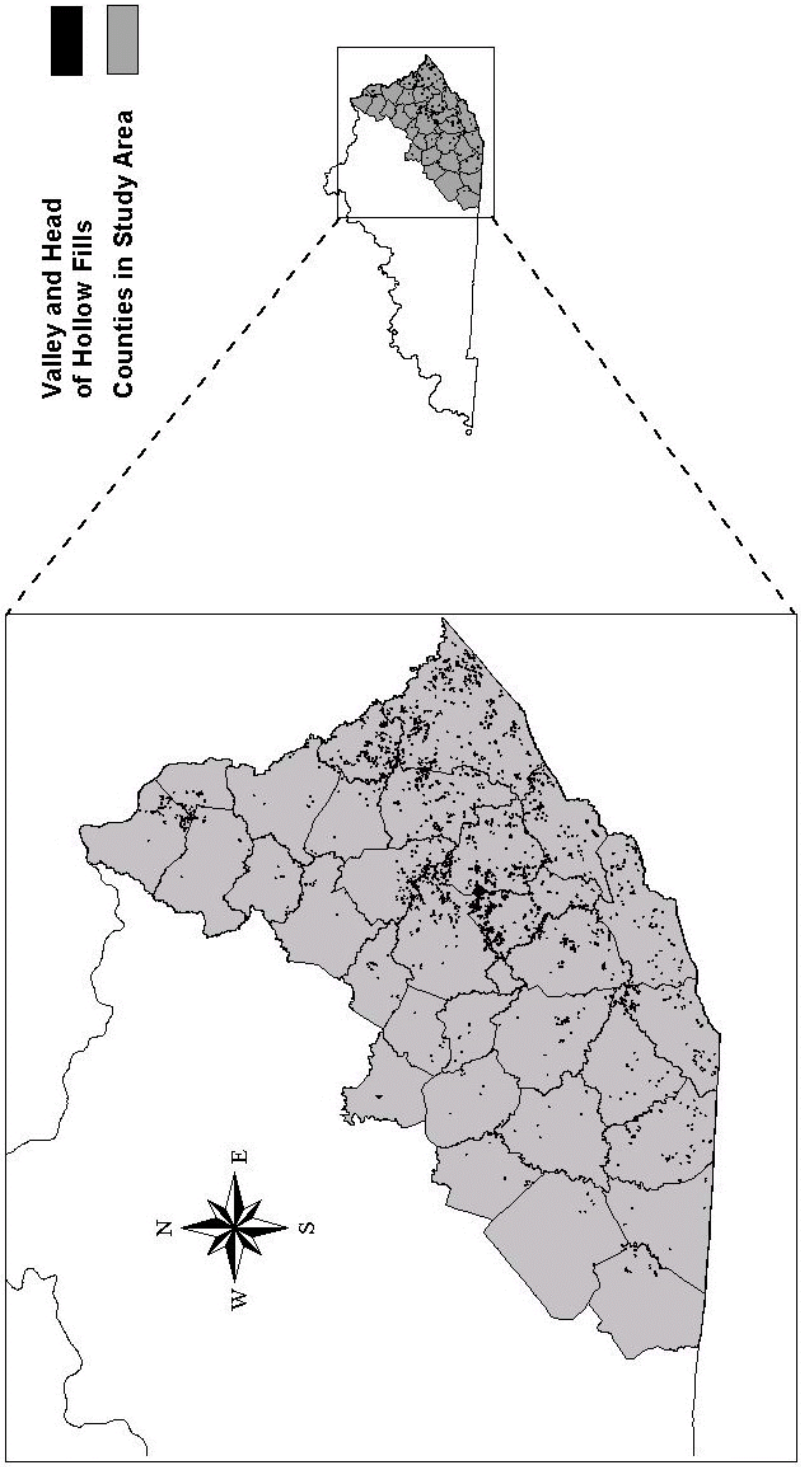


Figure III.K-9: Tennessee Fill Inventory Study Area

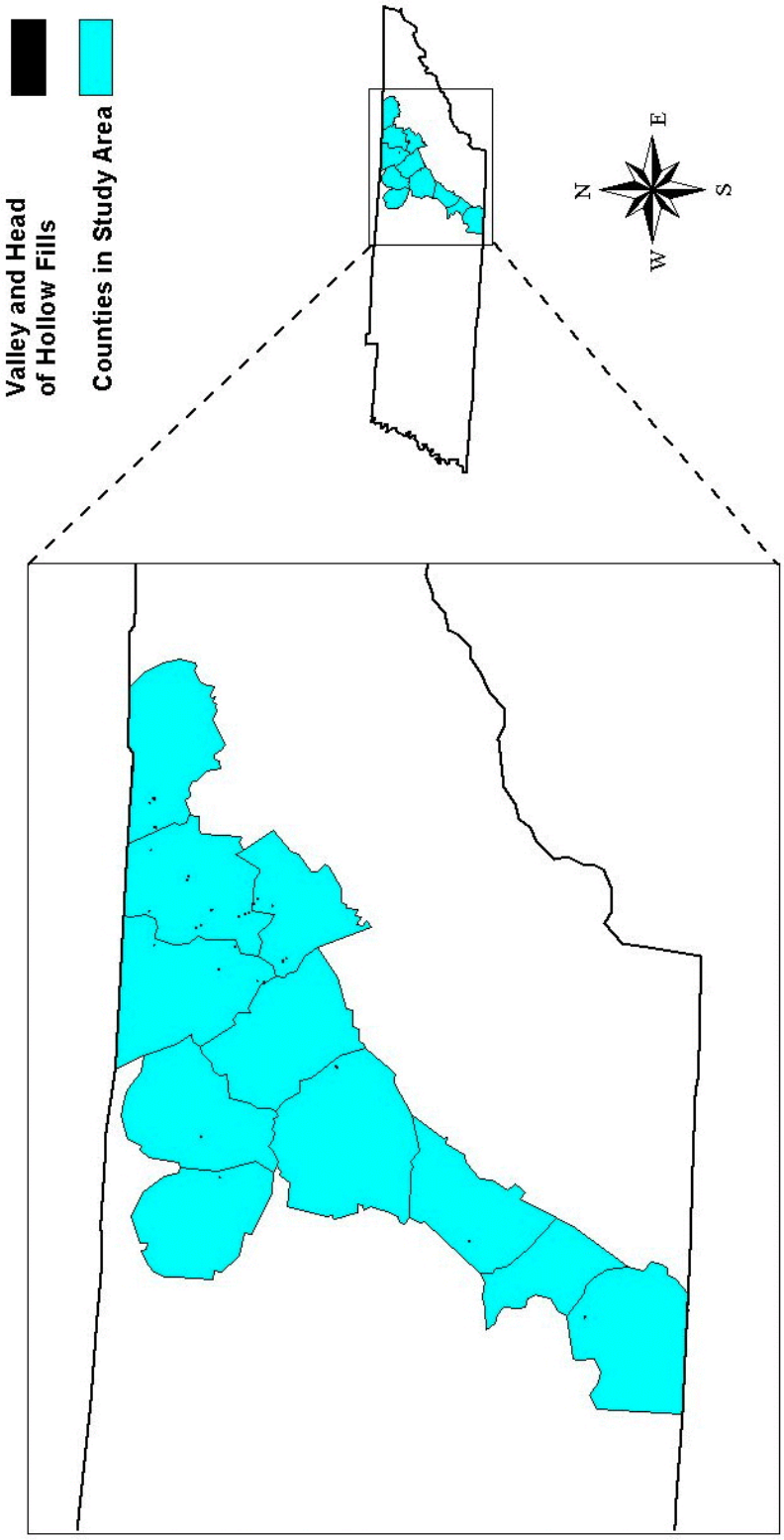


Figure III.K-10: Virginia Fill Inventory Study Area

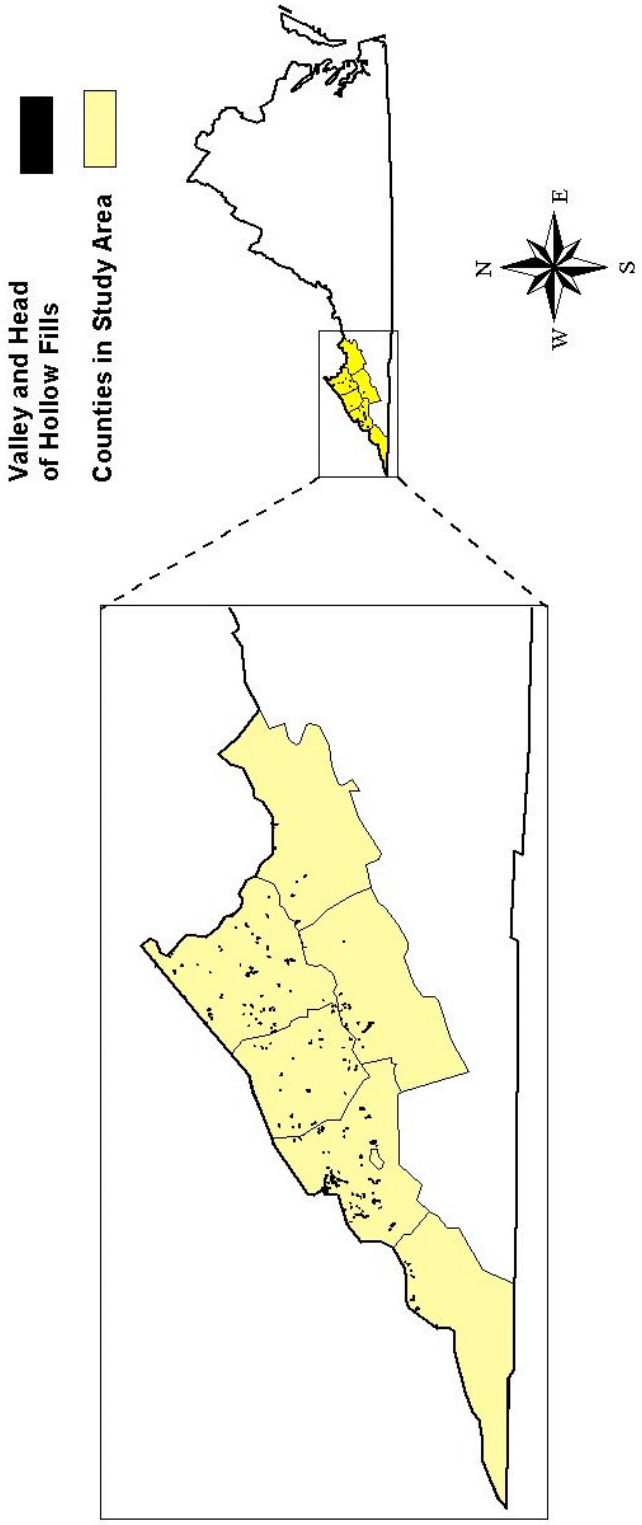
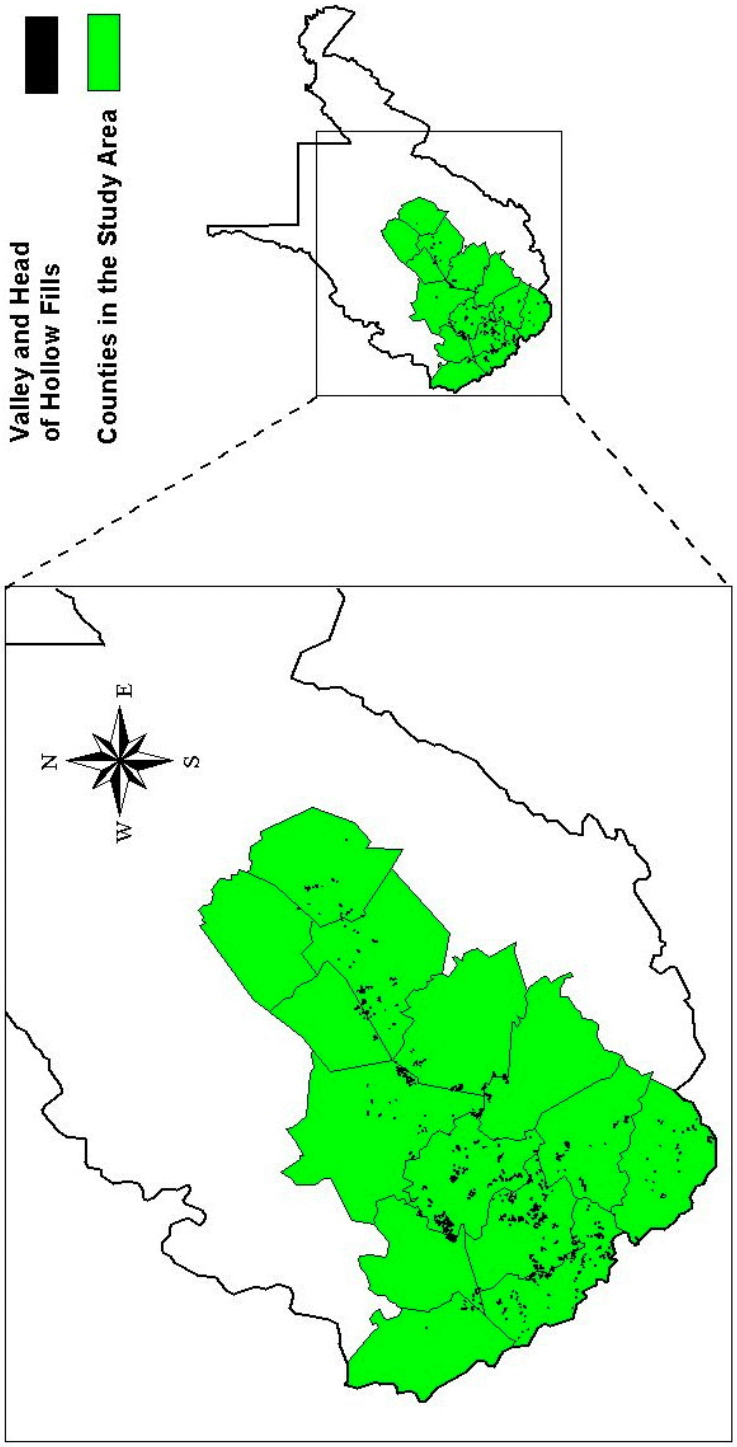


Figure III.K-11: West Virginia Fill Inventory Study Area



a. Regional Valley Fill Trends

Figure III.K-12 is the number of valley fills approved in each of the states contained in the study area for the period from 1985 through 2001. A total of 6697 valley fills were approved during this period.

Figure III.K-12 Total Number of Valley Fills Approved in States and Region

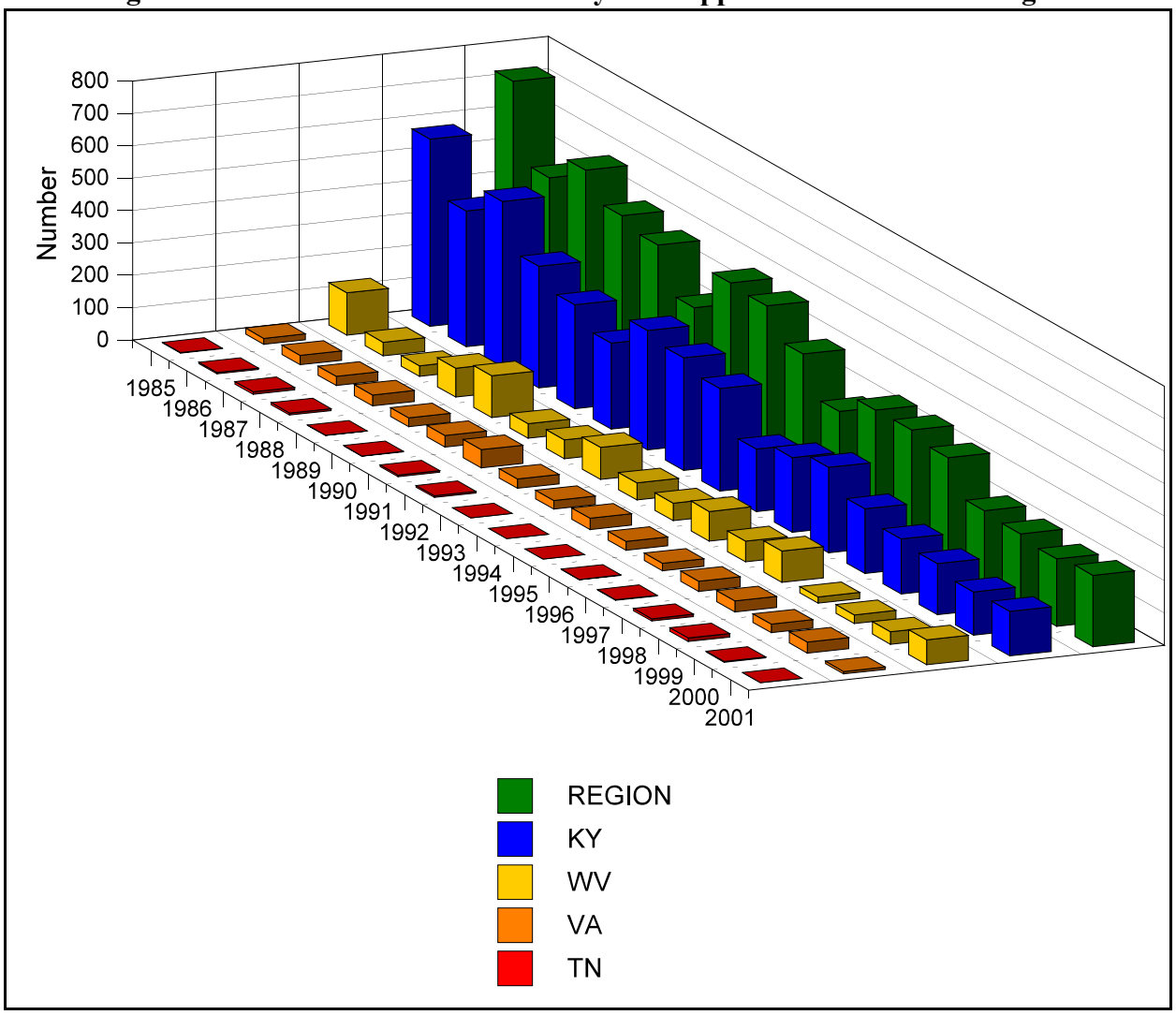


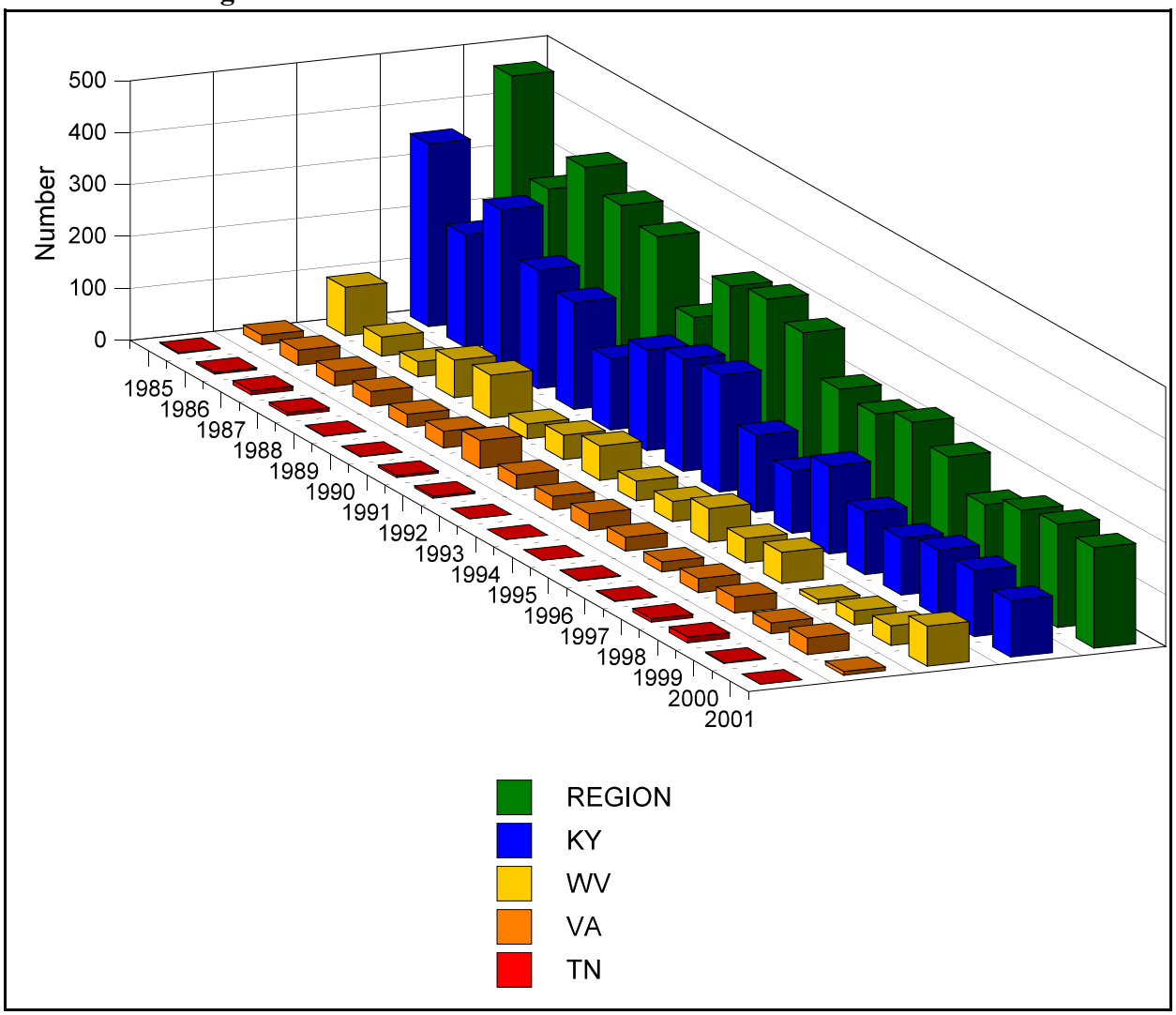
Table III.K-1 provides yearly data for the number of valley fills approved in states contained in the study area.

Table III.K-1
Valley Fills Approved in States and Region

Year	Kentucky	Tennessee	Virginia	West Virginia	Region
1985	578	2	18	131	729
1986	420	4	29	42	495
1987	513	8	28	33	582
1988	376	6	34	89	505
1989	321	1	27	129	478
1990	266	1	36	45	348
1991	369	5	56	58	488
1992	348	5	29	99	481
1993	317	0	26	53	396
1994	193	0	35	54	282
1995	231	0	27	92	350
1996	264	1	23	64	352
1997	200	2	31	97	330
1998	170	7	34	19	230
1999	158	11	26	27	222
2000	134	2	34	38	208
2001	137	0	7	77	221
Total	4995	55	500	1147	6697

Figure III.K-13 is the number of valley fills that were constructed or may be constructed in each of the study states for the period from 1985 through 2001. A total of 4484 (67 percent) valley fills out of the 6697 approved were constructed or may be constructed.

Figure III.K-13 Trends in Valley Fills Constructed or Proposed to be Constructed by States and Region



b. Kentucky Valley Fill Trends

During the period from 1985 through 2001, a total of 6,446 new permanent program permits were issued in Kentucky (OSM's Annual Reports from 1985-2001). Of these, 3,837 were new permits within the study area. The other 2,609 were in western Kentucky, were issued under the now repealed two-acre exemption, or were transfers or successions of existing operations. (SMCRA originally exempted any operation affecting 2 acres or less from requirements to comply with the standards of the Act. Most states still required permits on such sites and required reclamation to state standards. Due to widespread abuse of this provision, the 2-acre exemption was repealed in 1987.) Within the study area, 2,404 permits were issued without valley fills, and 1433 permits were issued with 4995 valley fills. Four thousand one hundred and thirty seven (4137) fills were approved on 961 surface mines, 738 were approved on 393 underground operations, and 120 were approved on 79 operations of other types (preparation plants, refuse fills, roads, tipples, etc. Figure III.K-14 shows that the number of permits issued, with or without valley fills, generally decreased through the period. During the period from 1990 through 2001, the number of permits (with or without valley fills) decreased 54 percent. Figure III.K-14 also shows that the number of fills decreased 48 percent during this same period. Including all permits issued, an average of 1.79 valley fills per permit was approved for the period 1990 through 2001. For permits containing approved valley fills, the average number of valley fills per permit was 3.6 for this same period. The range of valley fills issued per permit for the same period was zero to 31.

Figure III.K-14 Total Number of Fills Approved in Kentucky

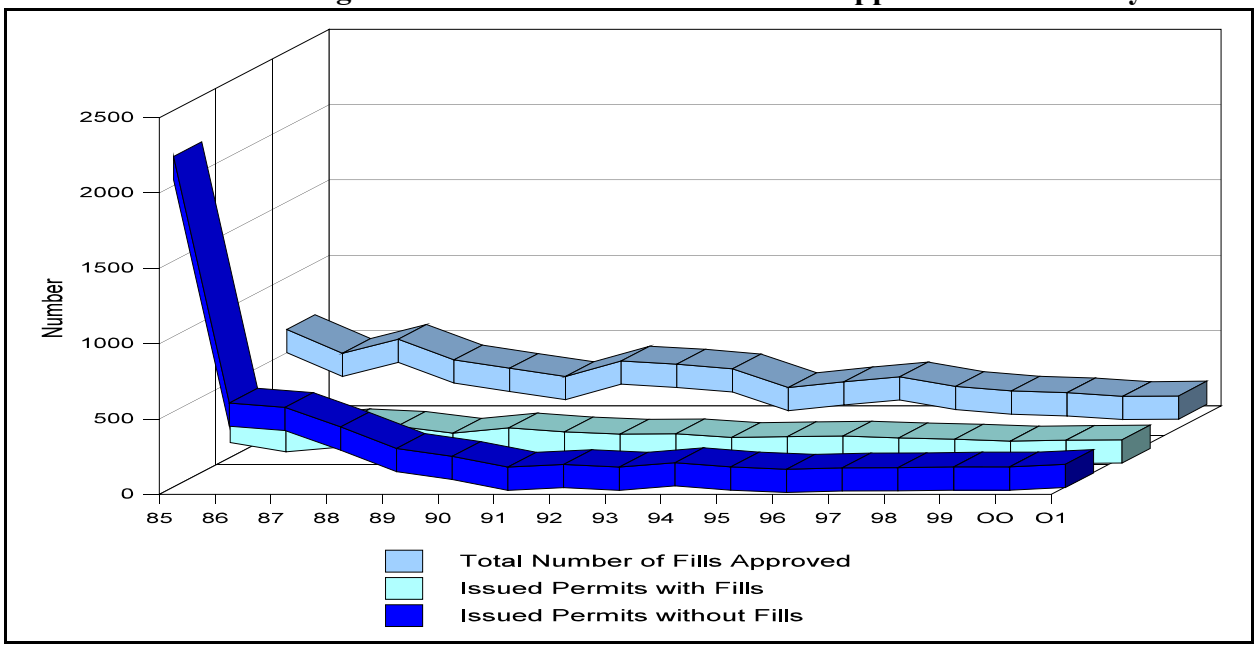
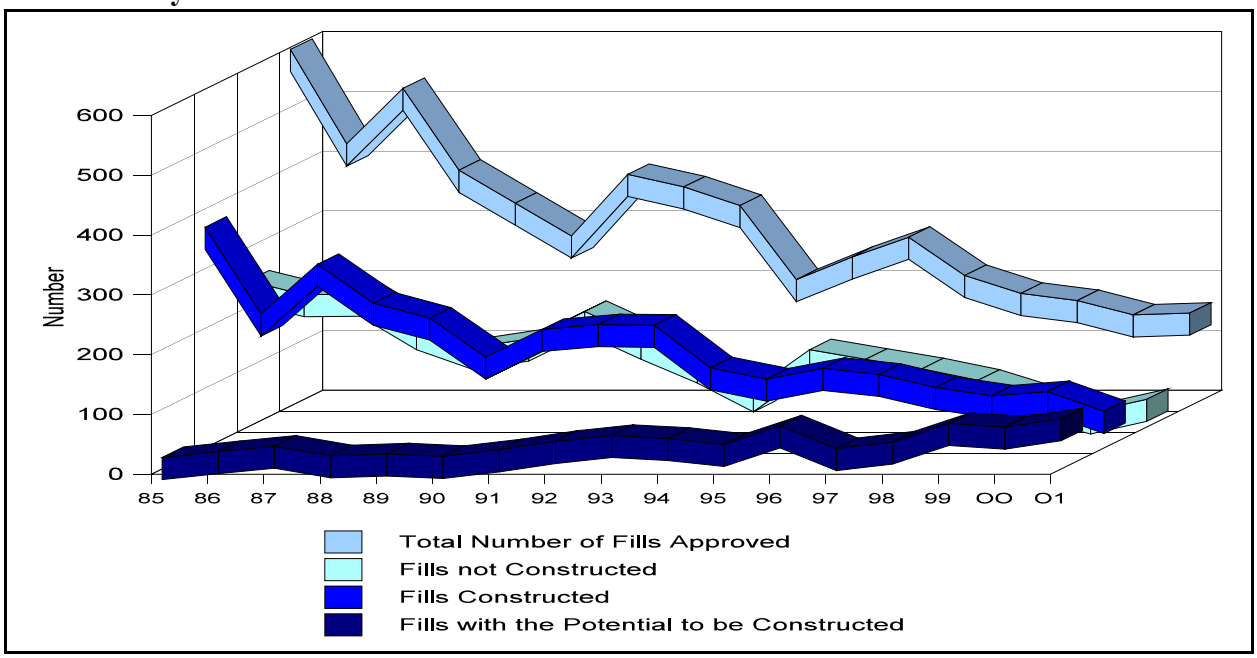


Figure III.K-15 shows trends in Kentucky valley fills constructed, or that having the potential to be constructed due to ongoing mining activity, during the period from 1985 through 2001. A total of 3117 (62 percent) of the 4996 approved valley fills are either constructed or may be constructed. The other 1879 valley fills will not be built because the bonds have either been released or forfeited for those permits.

Figure III.K-15 Trends in Valley Fills Constructed or Proposed to be Constructed in Kentucky



c. Tennessee Valley Fill Trends

Tennessee had a relatively small number of permits issued with valley fills. These limited data inhibit a trend analysis. Nonetheless, trends have been prepared for comparison to the other states. During the period from 1985 through 2001, a total of 236 new permanent program permits were issued in Tennessee (OSM's Annual Reports from 1985-1999). Thirty-five permits were issued with 55 valley fills. The other 201 permits were approved without valley fills. Figure III.K-16 shows that the number of permits issued with or without valley fills varied slightly during the period from 1985 through 2001, with one exception. An anomaly involving an increase in the number of valley fills was noted in 1999. This anomaly is related to one permit with nine valley fills that was issued in 1999. The average number of valley fills issued per permit is 0.62. The range of valley fills issued on permits is zero to nine.

Figure III.K-16 Total Number of Valley Fills Approved in Tennessee

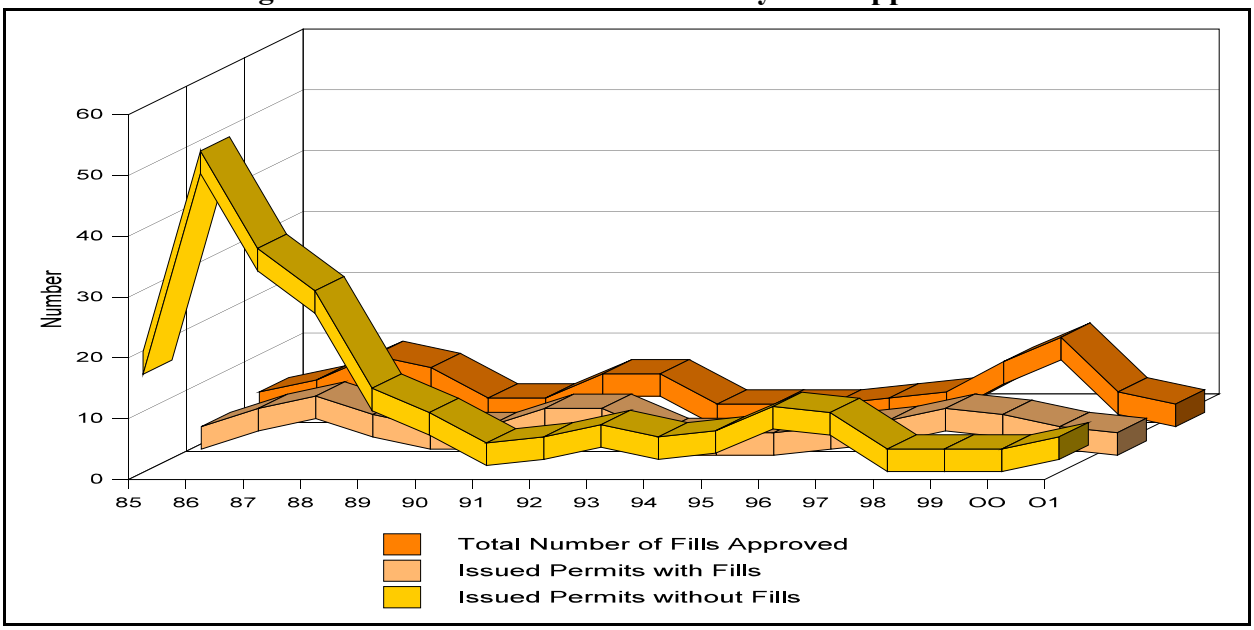
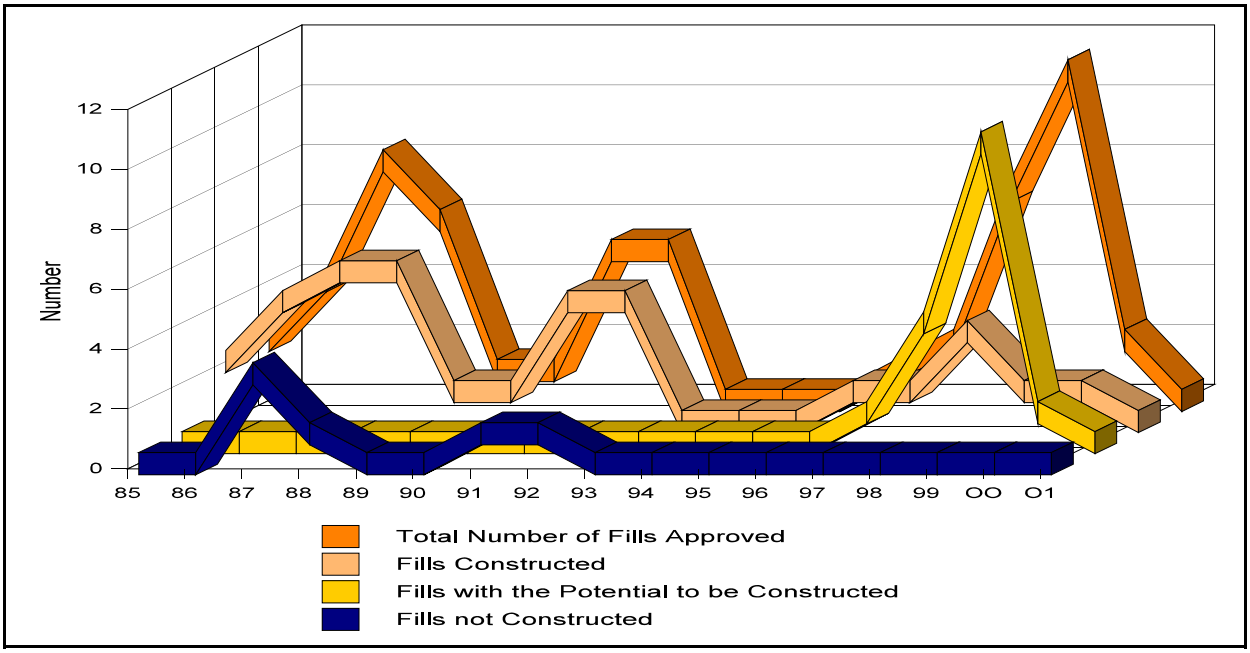


Figure III.K-17 shows trends in valley fills constructed or having the potential to be constructed in Tennessee during the period from 1985 through 2001. A total of 48 (87 percent) of the 55 approved valley fills are either constructed or have the potential to be constructed. The other seven valley fills will not be built.

Figure III.K-17 Trends in Valley Fills Constructed or Proposed to be Constructed in Tennessee



d. Virginia Valley Fill Trends

During the period of 1985 through 2001, a total of 916 new permanent program permits were issued in Virginia (OSM's Annual Reports from 1985-2001). Of these, 194 were issued under the now repealed two-acre exemption or were transfers or repermits of existing operations leaving 722 permits where permanent program standards would have applied to valley fills. Of these 722 permits, 493 were issued without valley fills, and 229 were issued with 500 valley fills. Three Hundred and thirty valley fills were approved on 123 surface mines, 45 were approved on 39 underground operations, and 125 were approved on 74 operations of other types (preparation plants, refuse fills, roads, tipples, etc.) Figure III-K-18 shows that, during the last ten years, the number of permits and valley fills issued each year have remained relatively consistent throughout the period with a few deviations. An average number of 2.7 valley fills per permit was approved for the period 1990 through 2001. The range of valley fills issued on permits for the same period is zero to 11.

Figure III-K-18 Total Number of Fills Approved in Virginia

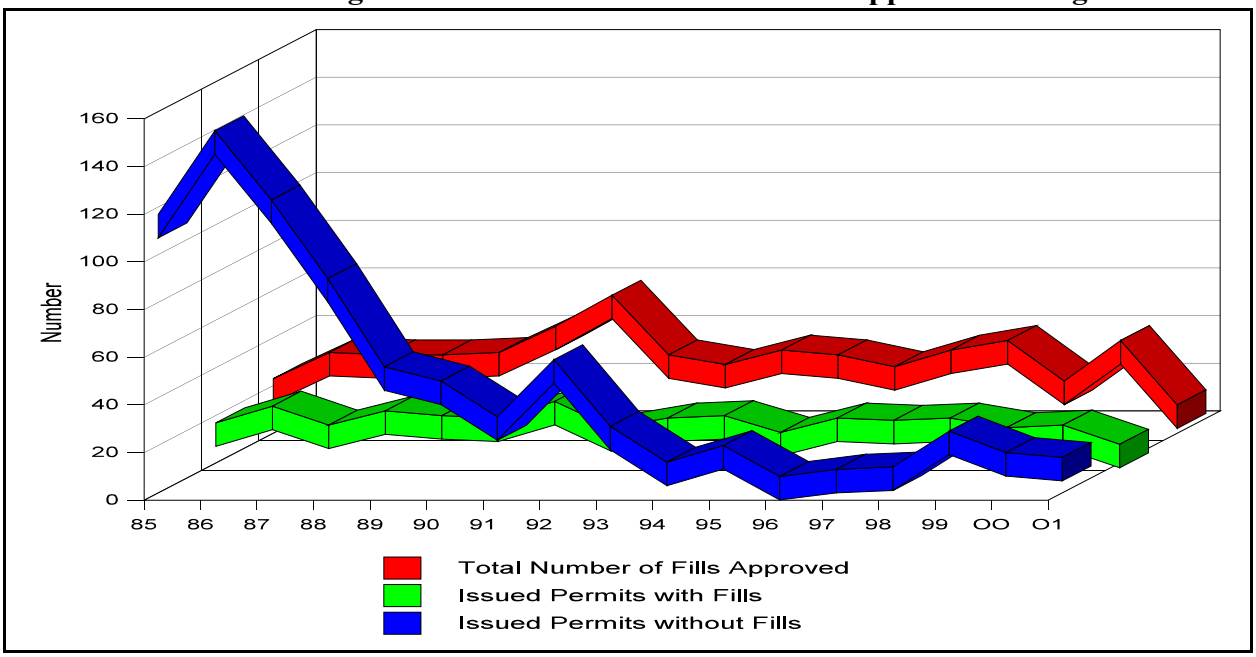
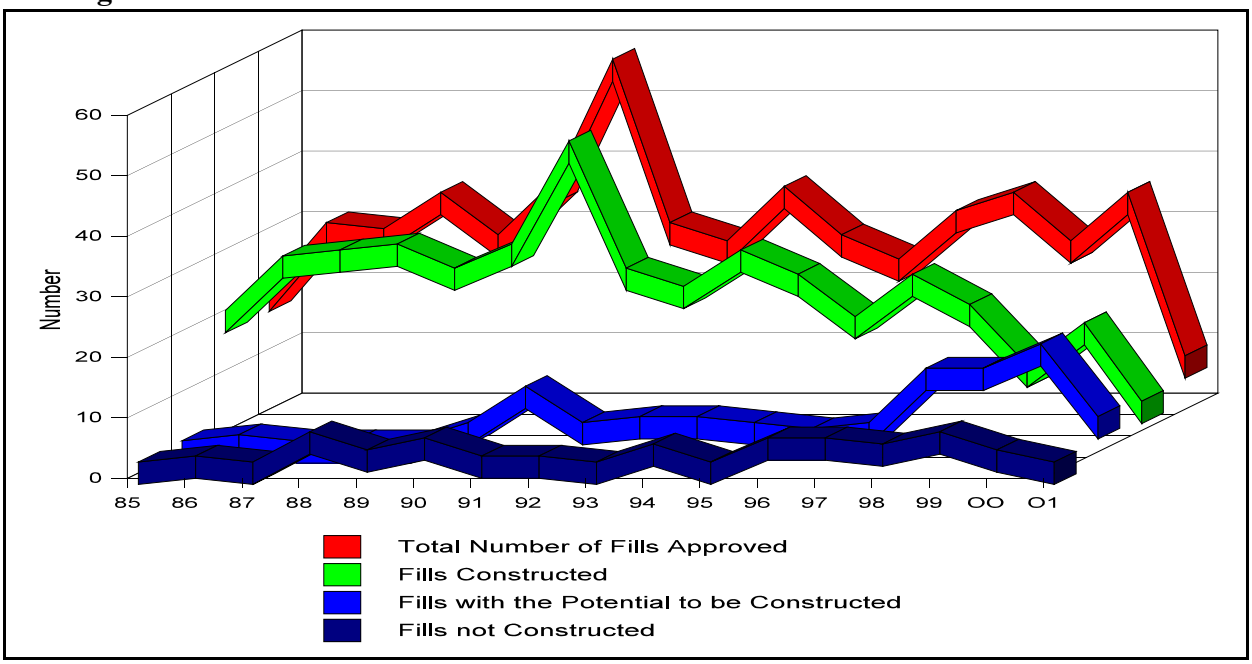


Figure III.K-19 shows trends in valley fills constructed, or that having the potential to be constructed due to ongoing mining activity, during the period from 1985 through 2001. A total of 465 (93 percent) of the 500 approved valley fills are either constructed or may be constructed. The other 35 valley fills will not be built because the bond has either been released or forfeited for those permits.

Figure III.K-19 Trends in Valley Fills Constructed or Proposed to be Constructed in Virginia



e. West Virginia Valley Fill Trends

During the period from 1985 through 2001, a total of 2,639 new permanent program permits were issued in West Virginia (OSM's Annual Reports from 1985-1999). Three hundred and forty two (342) permits were issued with 1147 valley fills. The other 2,297 permits were approved without valley fills. Figure III.K-20 shows marked variability during the period from 1985 through 2001. The figure suggests a decrease in the number of permits issued without valley fills, while the number of permits issued with valley fills has varied during the period. Figure III.K-20 also shows that the number of fills decreased during the period from 1990 through 2001 from a high of 91 fills in 1995 to a low of 19 fills in 1998. An average of 0.6 valley fills per permit was approved for the period 1990 through 2001. The range of valley fills issued on permits for the same period is zero to13.

Figure III.K-20 Total Number of Valley Fills Approved in West Virginia

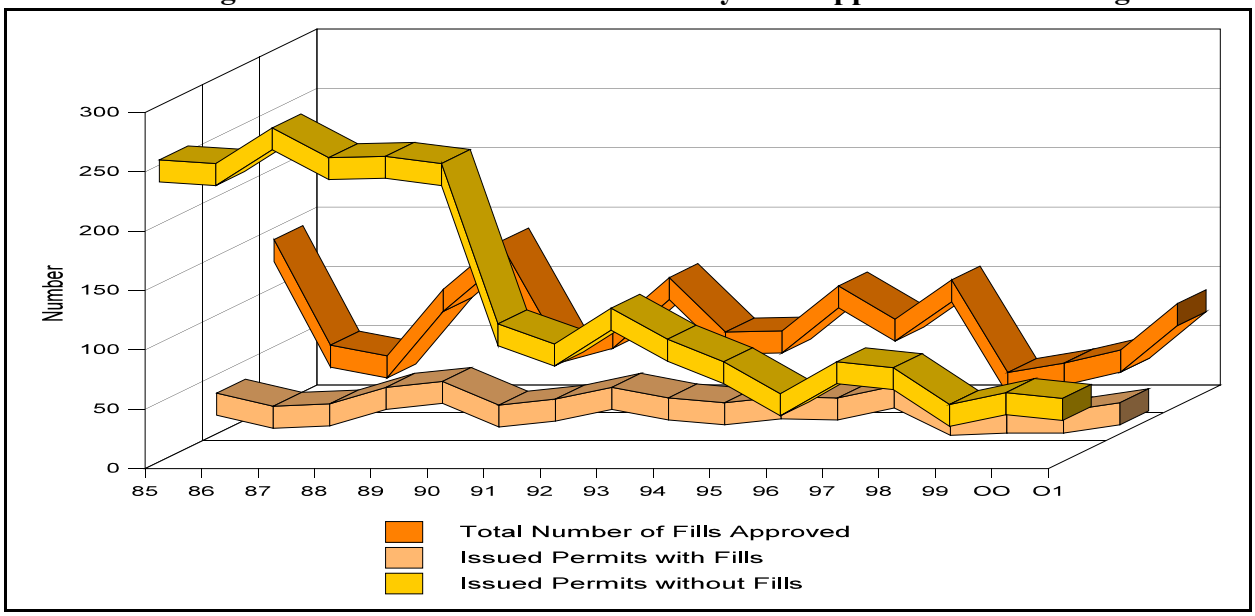
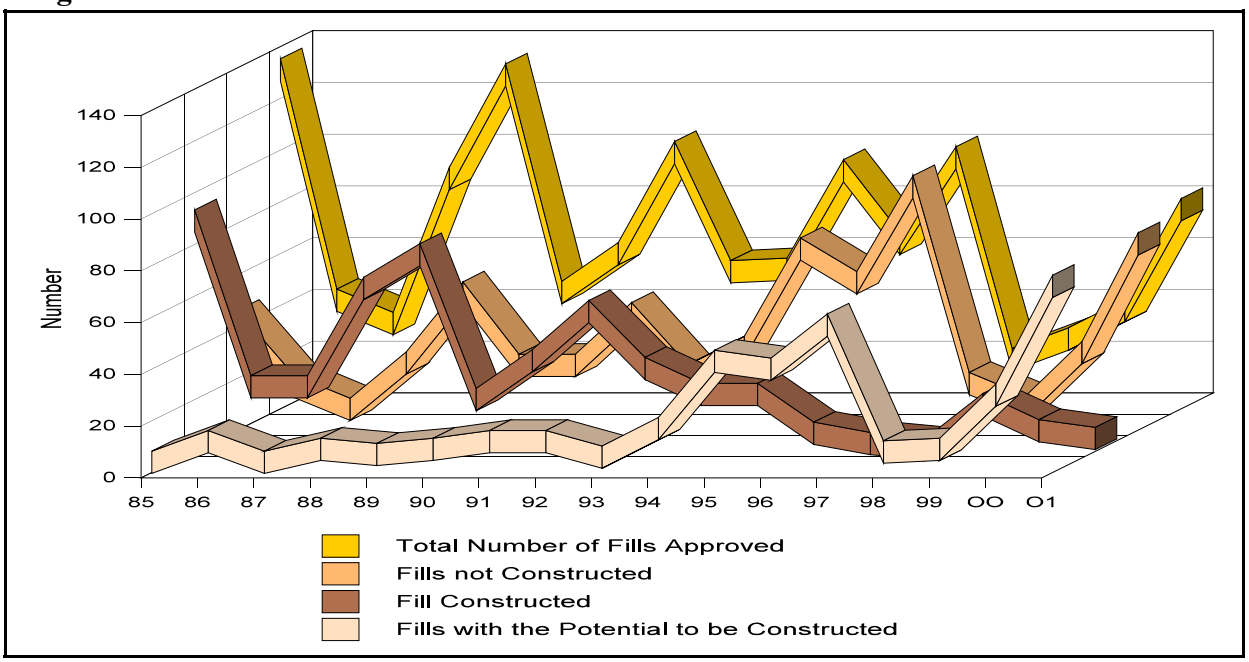


Figure III.K-21 shows trends in valley fills constructed or that having the potential to be constructed in West Virginia during the period from 1985 through 2001. A total of 856 (75 percent) of the 1147 of the approved valley fills are either constructed or may be constructed. The other 291 valley fills will not be built because the bonds have either been released or forfeited for those permits.

Figure III.K-21 Trends in Valley Fills Constructed or Proposed to be Constructed in West Virginia



3. Trends in Valley Fills Size

As with total excess spoil disposal, trends for individual valley fill sizes were developed for the Fill Inventory Study. For the EIS, available electronic databases were reviewed for the four states to provide an assessment of trends in valley fill size over time. These are similarly representative of valley fills that were proposed in permit applications, some of which may not have been or will not be constructed. The following summarizes the findings for the four states and the region.

a. Regional Valley Fill Size Trends

Figure III.K-22 is the total acreage of valley fills approved in each of the states contained in the study area for the period from 1985 through 2001. A total of 83,797 acres of land is covered by 6697 valley fills approved during the period.

Figure III.K-22 Trends in Valley Fill Acreage in States and Region

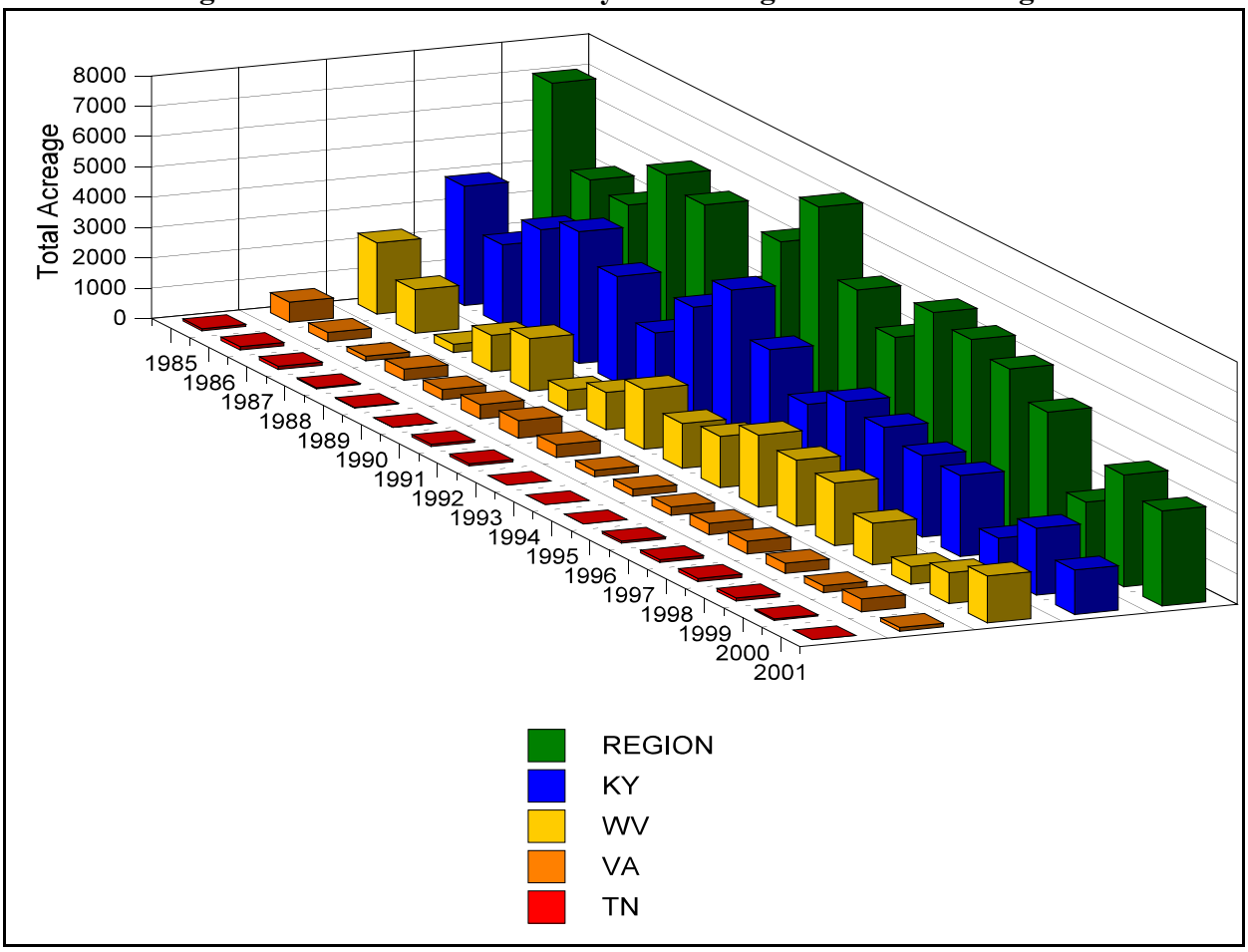


Table III.K-2 provides yearly data for total valley fill footprints approved, valley fill average sizes, and the range of valley fill sizes for the states within the study area.

Table III.K-2

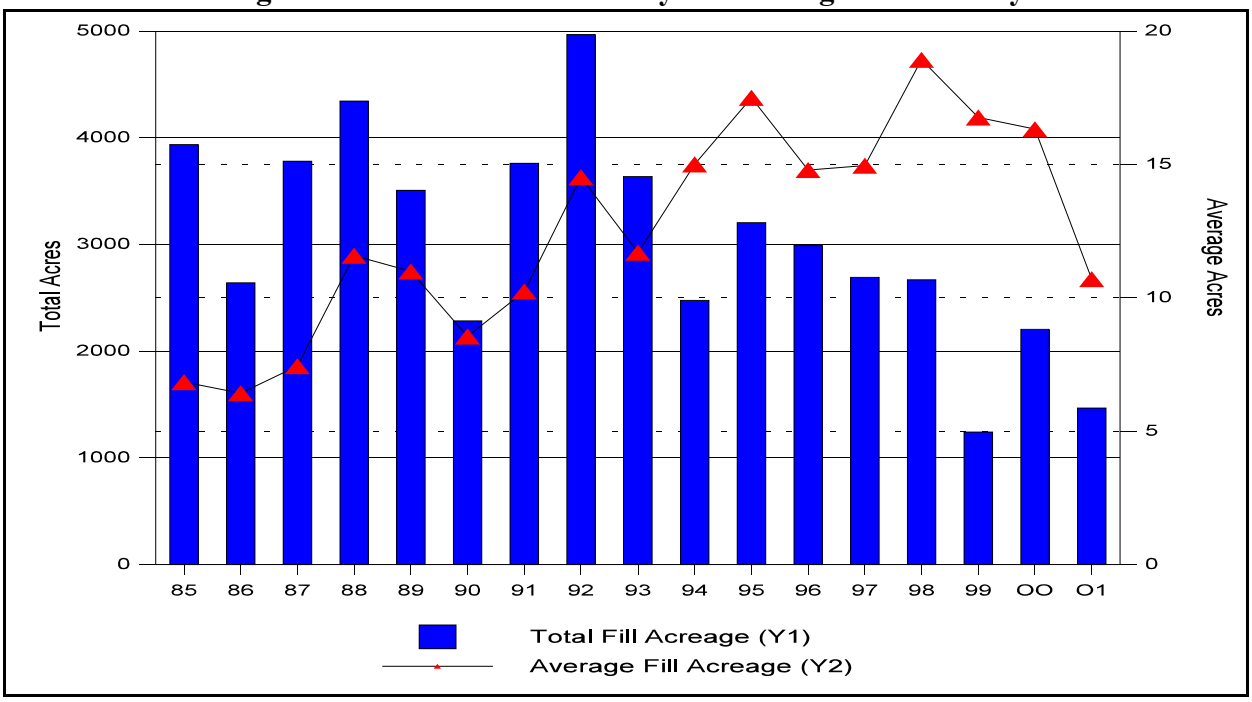
Year	Valley Fill Footprint Approved in Acres				Valley Fill Footprint Average Size in Acres				Range of Valley Fill Footprint Size in Acres			
	KY	TN	VA	WVA	KY	TN	VA	WVA	KY	TN	VA	WVA
1985	3,935	69	666	2,342	6.84	34.50	37.00	17.88	0.2-107	31-38	0.3-367	0.5-130
1986	2,640	115	306	1,437	6.42	28.75	10.56	34.24	0.2-77	2-81	0.5-55	0.3-272
1987	3,778	99	154	276	7.44	12.38	5.91	8.36	0.1-86	1-51	0.6-33	1.5-31
1988	4,342	34	367	1,205	11.58	5.67	10.80	13.54	0.5-188	1-26	0.6-147	0.6-68
1989	3,506	21	325	1,735	10.99	21.00	12.03	13.45	0.5-117	21	0.5-126	0.3-88
1990	2,282	3	473	673	8.55	3.00	13.15	14.98	0.4-62	3	0.2-160	0.7-58
1991	3,759	76	582	1,229	10.24	15.20	10.77	21.20	0.5-121	1-33	0.4-101	0.3-167
1992	4,966	73	419	1,974	14.52	14.60	14.97	19.95	0.5-174	2-59	0.6-99	0.6-153
1993	3,635	0	216	1,482	11.69	0	9.46	27.96	0.6-94	0	0.7-33	1.2-161
1994	2,475	0	235	1,692	15.00	0	7.58	31.30	0.6-99	0	0.6-69	0.5-256
1995	3,202	0	283	2,372	17.50	0	10.48	25.79	1.0-645	0	0.6-36	1.1-203
1996	2,988	69	374	2,179	14.79	69.0	16.24	38.05	0.2-134	69	0.3-56	0.2-216
1997	2,691	93	425	2,062	14.95	46.50	13.70	21.26	0.4-129	3-90	0.1-52	0.6-96
1998	2,668	109	333	1,379	18.92	15.57	9.78	72.60	0.5-173	2-65	0.8-55	1.2-473
1999	1,240	104	226	580	16.76	9.45	13.27	21.5	1.4-114	4-21	2.1-71	0.9-80
2000	2,203	44	425	1015	16.32	22.0	12.51	26.22	0.4-91		0.2-47	1.8-27
2001	1,465	0	126	1546	10.7	0	18.03	20.07	.14-92	0	8-30	0.8-99
Total	**51775**	**909**	**5935**	**25178**	**10.36**	**16.52**	**11.79**	**22.02**	**0.1-645**	**1-90**	**0.1-367**	**0.2-473**

b. Kentucky Valley Fill Size Trends

Figure III.K-23 shows that for the period from 1985 through 2001, the total approved valley fill acreage has generally decreased from a high of 4,966 acres in 1992 to a low of 1,240 acres in 1999. Although the total acreage of valley fills permitted increased again in 2000 to 2,203 acres, it decreased again in 2001 to 1,465 acres. The figure also shows that the average approved valley fill size has generally increased during the period, from a low of 6.42 acres in 1986 to a high of 18.92 acres in 1998.

Total valley fill acreage approved for the period is 51,775 acres. The average total valley fill acreage approved per year is 3,045 acres. The average approved valley fill size for the period is 10.36 acres. Individual approved valley fill acreage ranged from 0.1 acres in 1987 to 645 acres in 1995.

Figure III.K-23 Trends in Valley Fill Acreage in Kentucky

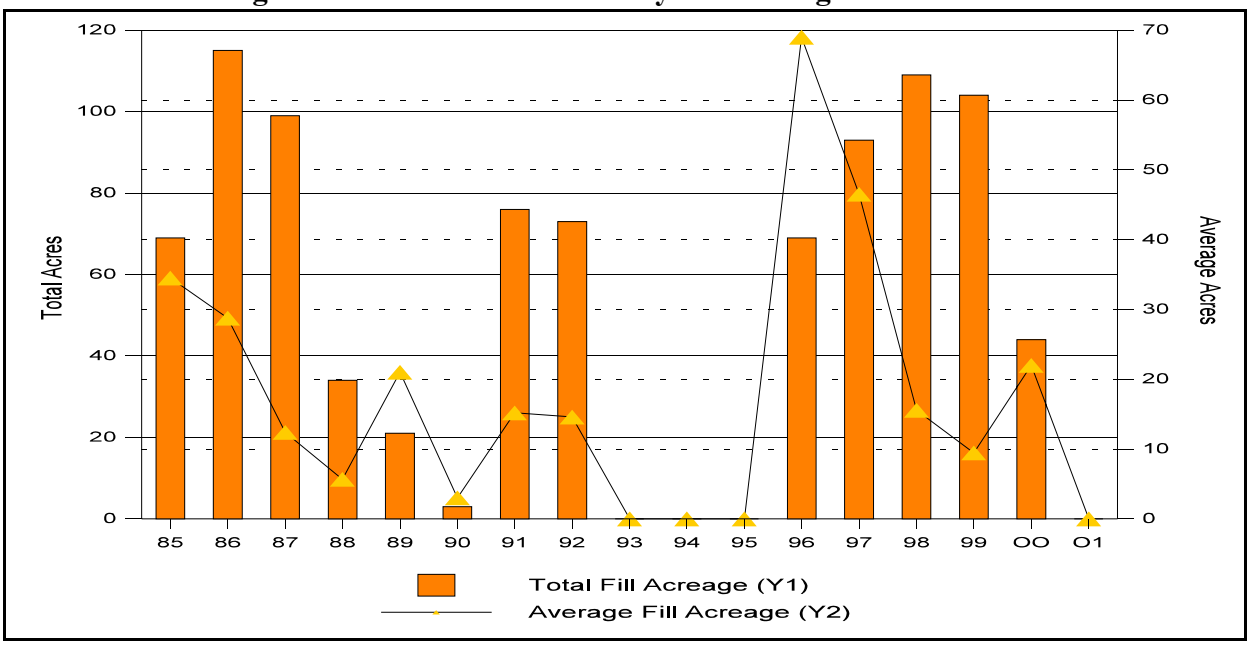


c. Tennessee Valley Fill Size Trends

As noted in Section III.K.2.c, Tennessee had a relatively small number of permits issued with valley fills. These limited data do not lend themselves well to a trend analysis, but Figure III.K-24 has been prepared for comparison to the other states. The high for total acreage approved was 115 acres in 1986. In some years, there were no permits issued with fills. The figure shows that the average approved valley fill size shows great variability, with a high of 69 acres in 1996, to a low of 3 acres in 1990.

Total valley fill acreage approved for the period is 909 acres. The average acreage approved per year is 52.88 acres. The average approved valley fill size for the period is 16.34 acres. Individual approved valley fill acreage ranged from 1 acre in a number of years to 90 acres in 1997.

Figure III.K-24 Trends in Valley Fill Acreage in Tennessee

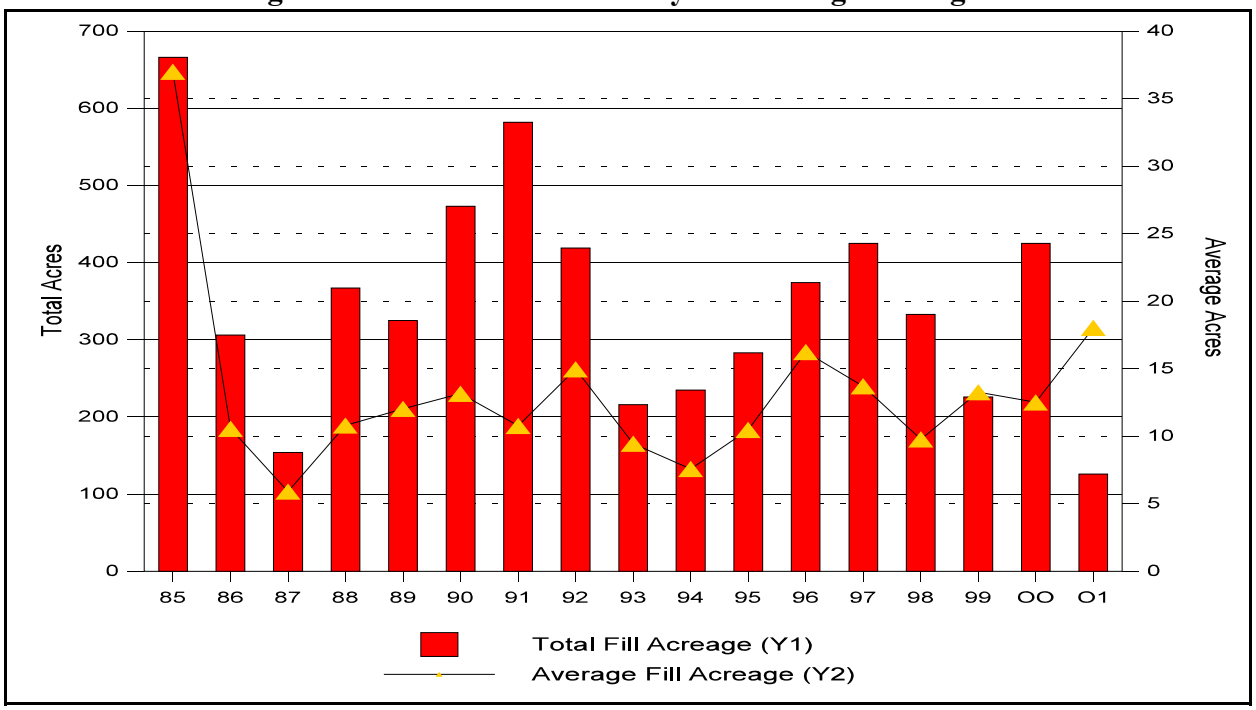


d. Virginia Valley Fill Size Trends

Figure III.K-25 shows great variability during the period from 1985 through 2001. Since 1990, the total approved valley fill acreage has generally declined with a few exceptions. In 1985, the approved total valley fill acreage was 666 acres and in 2001 it was 126 acres. The figure also shows that the average approved valley fill size varied from a high of 37 acres in 1985 to a low of 5.91 acres in 1987. Since 1990, the average approved valley fill size varied from a high of 16.24 acres in 1996 to a low of 7.58 acres in 1994.

The total valley fill acreage approved for the period is 5,935 acres. The average approved per year is 349 acres. The average approved valley fill size for the period is 11.79 acres. Individual approved valley fill acreage ranged from 0.1 acres in 1997 to 367 acres in 1985.

Figure III.K-25 Trends in Valley Fill Acreage in Virginia

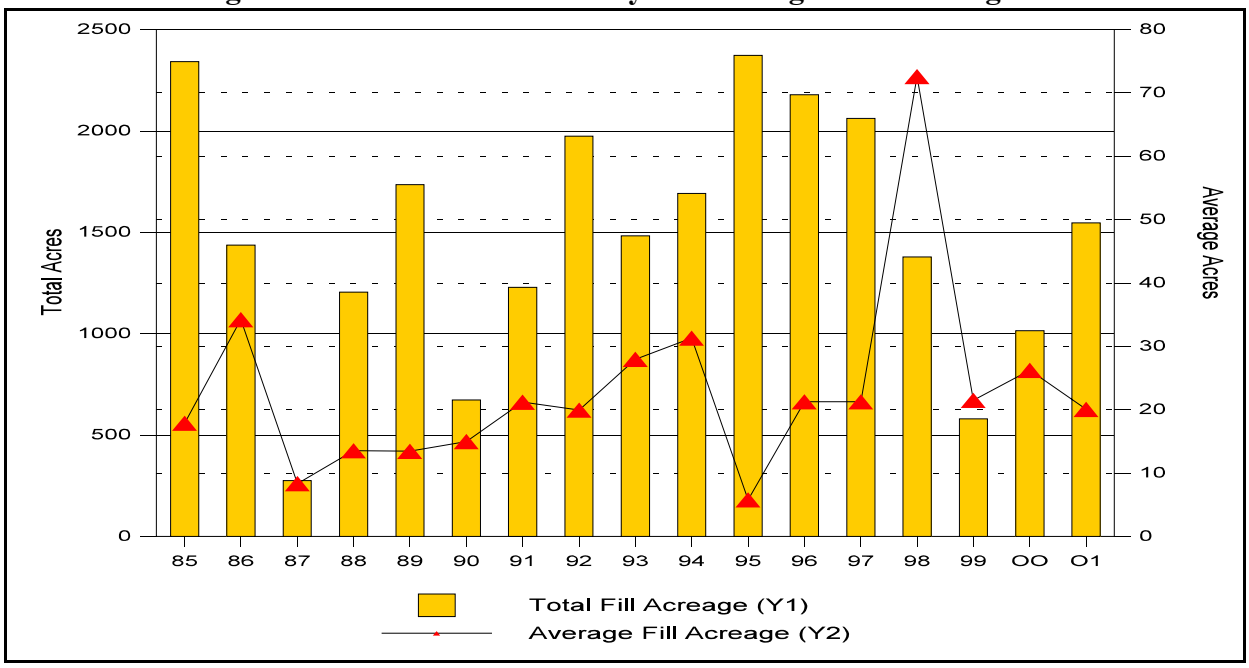


e. West Virginia Fill Size Trends

Figure III.K-26 shows a lot of variability during the period from1985 through 2001. The figure suggests that the total approved valley fill acreage has generally increased from a low of 276 acres in 1987 to a high of 2,372 acres in 1995. The figure also shows that the average approved valley fill size also has increased during the period with a high of 72.6 acres in 1998 to a low of 8.36 acres in 1987.

Total valley fill acreage approved for the period is 25,178 acres. The average acreage approved per year is 1,481 acres. The average approved valley fill size for the period is 22.02 acres. Individual approved valley fill acreage ranged from 0.2 acres in 1996 to 472.66 acres in 1998.

Figure III.K-26 Trends in Valley Fill Acreage in West Virginia



4. Trends in Watershed Size

As previously described, trends can be measured by the number of valley fills and their size. Another important aspect in evaluating valley fills and their impact on the environment is the impact to watersheds. This trend is very useful in evaluating and predicting overall impacts on the environment. The following provides a summary of trends in watershed sizes in each of the states within the study area.

a. Regional Watershed Trends

Valley fills are typically in headwater streams with varying sizes of watershed or drainage area above, or upstream, of the competed fill. Some valley fills may envelope the majority of the watershed, and others are farther downstream. The watershed acreage is determined by measuring the upland area above each fill toe. Figure III.K-27 is the total watershed acreage in which there are valley fills approved in each of the states contained in the study area for the period from 1985 through 2001. A total of 438,472 acres of watersheds are located above approved valley fills.

Figure III.K-27 Trends in Watershed Acreage in States and Region

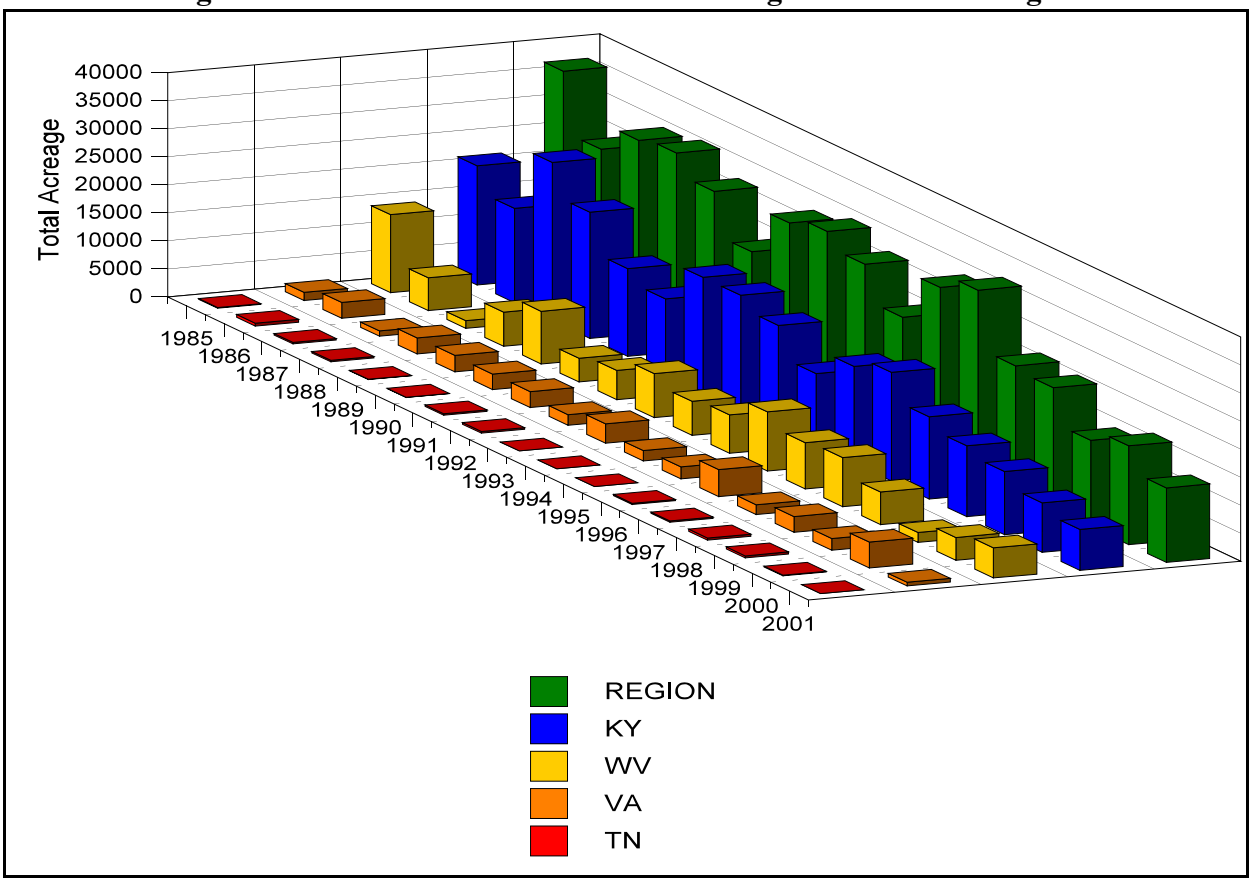


Table III.K-3 provides yearly data for watershed sizes for the states within the study area.

Table III.K-3
Watershed Impacts by States

Year	Total Watershed Impacted by Valley Fill Construction in Acres				Average Watershed Impacts by Valley Fill Construction in Acres			
	KY	TN	VA	WVA	KY	TN	VA	WVA
1985	21,262	150	1,430	13,938	36.8	75	79.5	106.40
1986	16,846	490	2,828	5,843	40.0	122.50	97.5	139.12
1987	28,234	269	915	1,379	55.0	33.63	33.9	41.79
1988	22,525	239	2,873	6,079	59.9	39.83	84.5	68.31
1989	15,646	45	2,944	9,429	48.6	45	109.0	73.09
1990	13,417	39	2,793	4,213	51.00	39	77.6	93.64
1991	20,464	255	2,823	5,228	55.3	51	50.4	90.14
1992	20,425	270	1,904	7,858	59.0	54	132.9	79.38
1993	18,237	0	3,454	6,085	58.1	0	132.9	114.82
1994	12,838	0	1,851	6,817	66.5	0	52.9	126.24
1995	17,305	0	2,112	10,575	74.3	0	78.2	114.95
1996	19,417	186	4,837	8,255	73.8	186	96.8	128.98
1997	14,662	234	1,741	8,773	73.3	117	54.4	90.45
1998	12,651	378	2,804	5,809	74.4	54	85.0	305.79
1999	11,259	364	2,071	1,744	71.7	33.09	79.7	64.60
2000	8,858	98	4,617	4,067	66.6	22	131.9	107.04
2001	7,301	0	632	5,387	50.7	0	90.3	70.88
Total	**281,347**	**3,017**	**42,629**	**111,479**	**51.78**	**54.85**	**78.41**	**97.28**

b. Kentucky Watershed Trends

Figure III.K-28 shows variability during the period from 1985 through 2001. Since 1990, the total watershed area impacted by valley fill construction has generally declined with a number of exceptions. In 1990, the total watershed area impacted by valley fill construction was 13,417 acres, and in 2001, it was 7,301 acres. The figure also shows that the average watershed acreage increased during the same period from a low of 51.00 acres in 1990 to 71.7 acres in 1999.

The total watershed acreage above valley fills constructed during the period is 281,355 acres. The average watershed size is 56.3 acres. Individual watershed acreage ranged from 0.8 acres in 1999 to 3,777 acres in 1987.

Figure III.K-28 Trends in Watershed Acreage in Kentucky

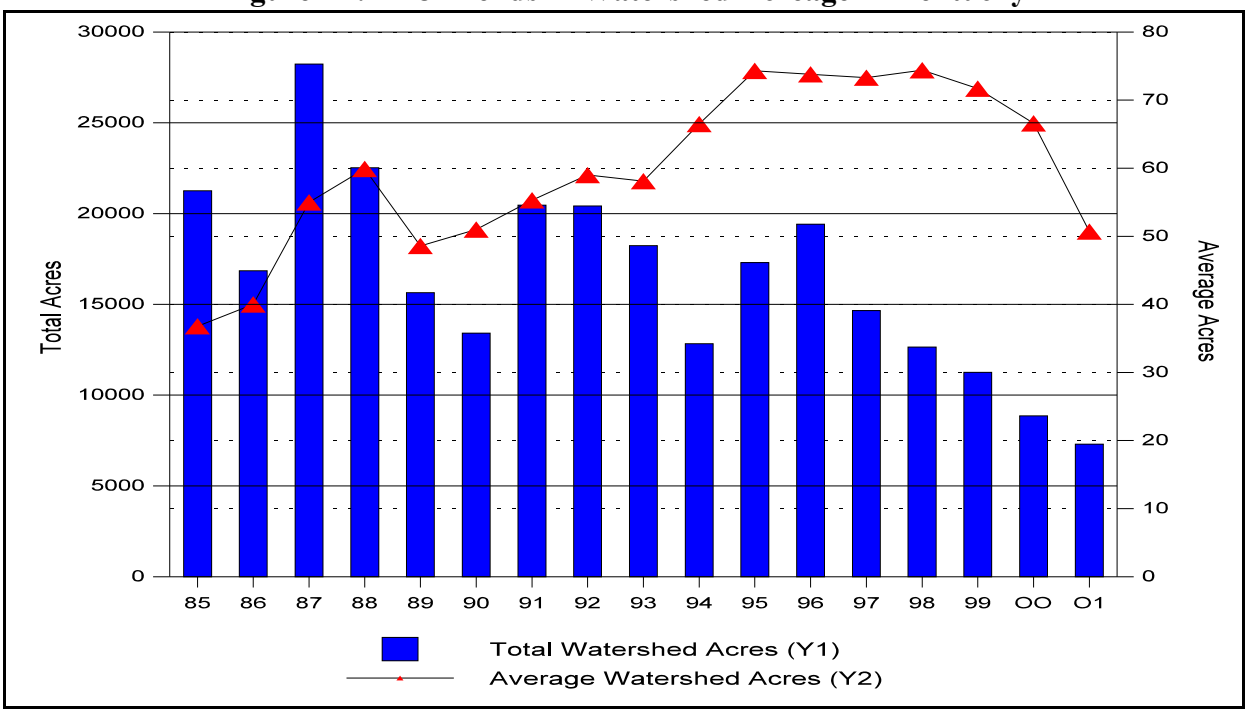


Table III.K-4 shows the distribution of watershed acres of valley fills approved in Kentucky for the period from 1985 through 2001. Eighty percent of the valley fills approved have watersheds less than 75 acres. As the table shows, 108 valley fills have a watershed greater than 250 acres in Kentucky.

Table III.K-4
Distribution of Watershed Sizes for Valley Fills in Kentucky

Watershed Acres	Year																	Total
	85	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	
Less than 75 Acres	519	378	432	289	275	216	308	262	253	138	165	193	136	116	104	972	121	4,002
75 Acres to less than 250 Acres	52	38	72	73	42	41	55	76	55	49	64	63	56	47	47	34	22	886
250 Acres and Greater	7	5	5	14	5	6	7	8	6	6	4	7	8	7	6	2	1	108

c. Tennessee Watershed Trends

As noted in Section III.K.2.c., Tennessee had a relatively small number of permits issued with valley fills. These limited data do not lend themselves well to a trend analysis, but Figure III.K-29 has been prepared for comparison to the other states. The high for total watershed acres with fills was 490 acres in 1986. In some years, there were no permits issued with fills. The figure shows variable average watershed acreage, with a high of 186 acres in 1996, and a low of 33.63 acres in 1987.

The total watershed acreage above valley fills constructed during the period is 3,017 acres. The average watershed size is 54.85 acres. Individual watershed acreage ranged from 2 acres in 1988 to 288 acres in 1998.

Figure III.K-29 Trends in Watershed Acreage in Tennessee

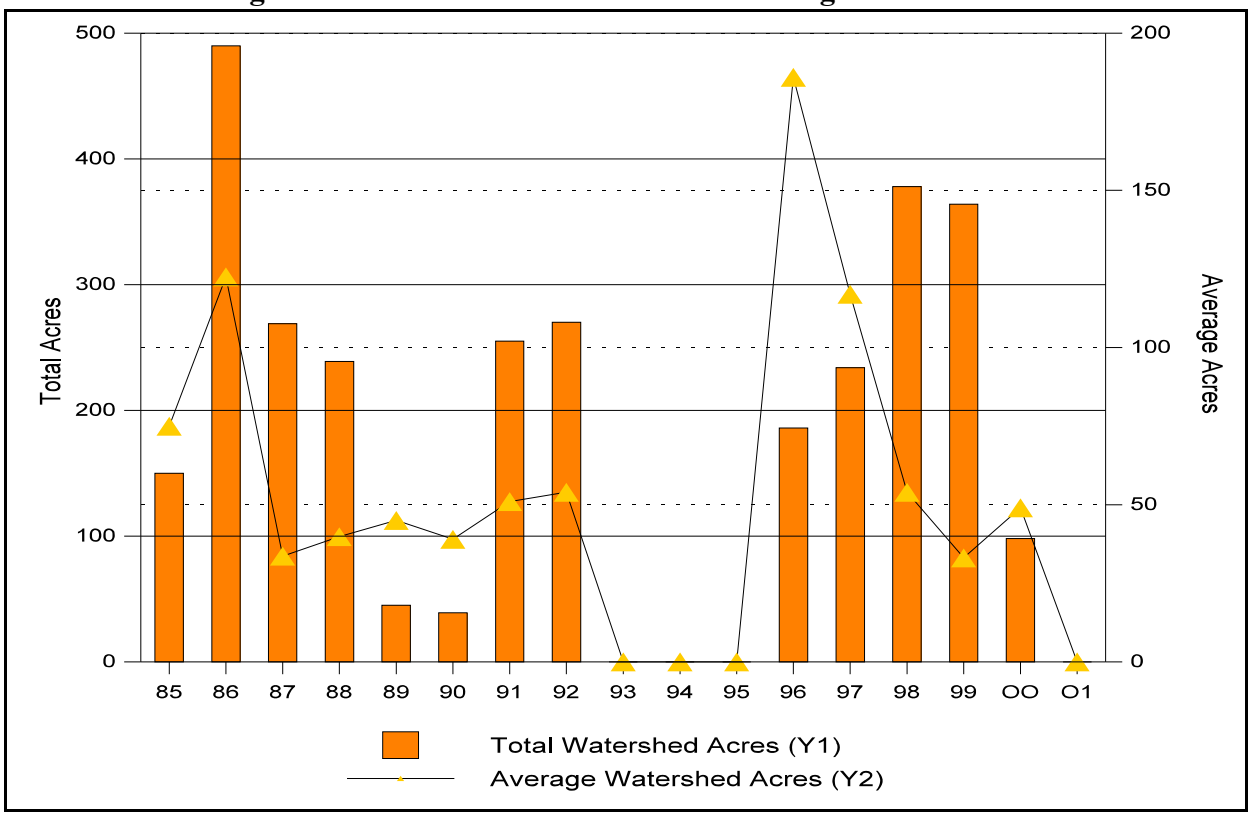


Table III.K-5 shows the distribution of watershed acres for valley fills approved in Tennessee for the period from 1985 through 1999. Seventy-nine percent of the valley fills approved have watersheds less than 75 acres. As the table shows, only one valley fill has a watershed greater than 250 acres in Tennessee.

Table III.K-5
Distribution of Watershed Sizes for Valley Fills in Tennessee

Watershed Acres	Year																	Total
	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	
Less than 75 Acres	1	2	8	4	1	1	4	4	0	0	0	0	1	6	10	2	0	44
75 Acres to less than 250 Acres	1	2	0	2	0	0	1	1	0	0	0	1	1	0	1	0	0	10
250 Acres and Greater	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

d. Virginia Watershed Trends

Figure III.K-30 shows variability during the period from 1985 through 2001. Since 1990, the total watershed acreage has been irregular but does show an a slight trend toward smaller totals despite two notable exceptions in 1996 and 2000. In 1996, the total watershed area impacted by valley fill construction was 4,837 acres, and in 2001, it was 632 acres. Between 1990 and 2001, the average acreage of impacted watersheds was 2,636 acres per year. The figure also shows that the average watershed acreage varied from a high of 132.9 acres in 1993 to a low of 50.4 acres in 1991.

The total watershed acreage above valley fills constructed during the period is 40,526 acres. The average watershed size is 81.05 acres. Individual watershed acreage ranged from 1.5 acres in 1987 to 1,238 acres in 1989.

Figure III.K-30 Trends in Watershed Acreage in Virginia

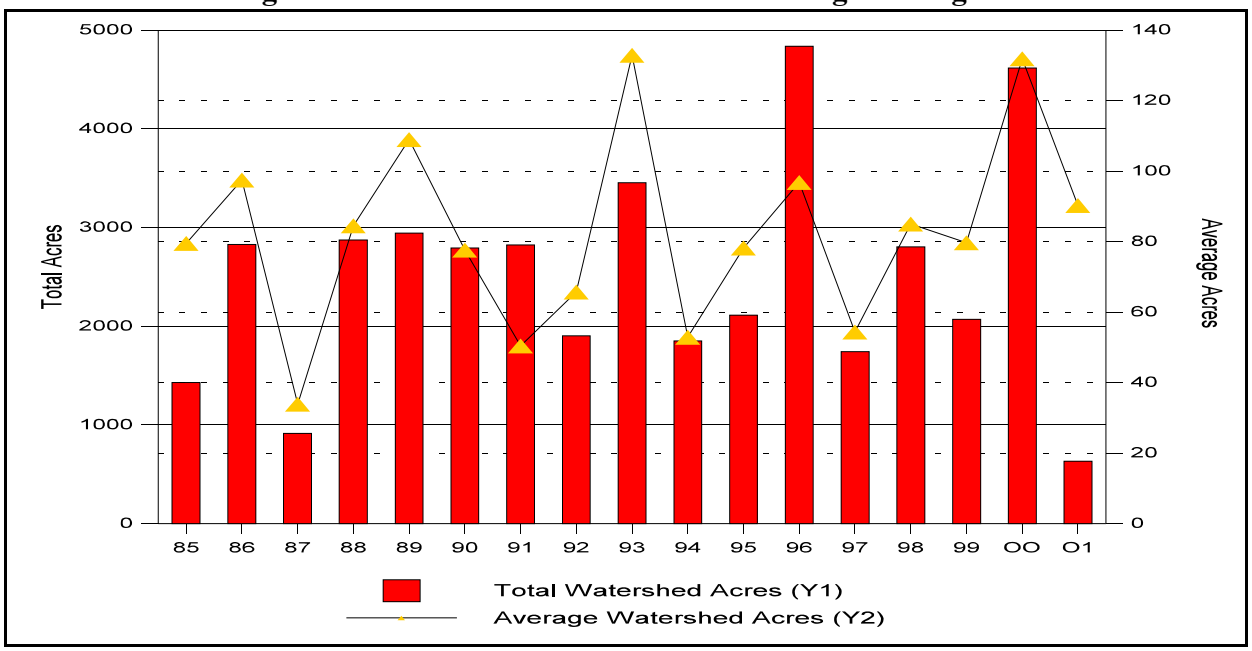


Table III.K-6 shows the distribution of watershed acres for valley fills approved in Virginia for the period from 1985 through 2001. Sixty eight percent of the valley fills approved have watersheds less than 75 acres. As the table shows, only 22 valley fills have a watershed greater than 250 acres.

Table III.K-6
Distribution of Watershed Sizes for Valley Fills in Virginia

Watershed Acres	Year																	Total
	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	
Less than 75 Acres	13	21	25	25	19	27	45	20	14	30	16	10	25	18	17	17	2	344
75 Acres to less than 250 Acres	4	6	2	8	6	8	9	8	7	4	11	12	7	15	8	14	5	134
250 Acres and Greater	1	2	0	1	2	1	2	1	5	1	0	1	0	0	1	4	0	22

e. West Virginia Watershed Trends

Figure III.K-31 shows variability during the period from 1985 through 2001. Between 1990 and 1997, the total watershed acreage impacted each year has generally increased. In 1998 and 1999 this acreage decreased significantly from a total of 8,773 acres in 1997 to only 1744 acres in 1999. In the last two years, there again appears to be an increase in the watershed sizes. The total watershed area impacted by valley fill construction has ranged from a high of 13,938 acres in 1985 to a low of 1,744 acres in 1999. The figure also shows that the average watershed acreage has gradually increased since 1987 from a low in 1987 of 41.79 acres to a high of 305.79 in 1998.

The total watershed acreage above valley fills constructed during the period is 111,479 acres. The average watershed size is 97.28 acres. Individual watershed acreage ranged from 0.2 acres in 1996 to 1,628 acres in 1985.

Figure III.K-31 Trends in Watershed Acreage in West Virginia

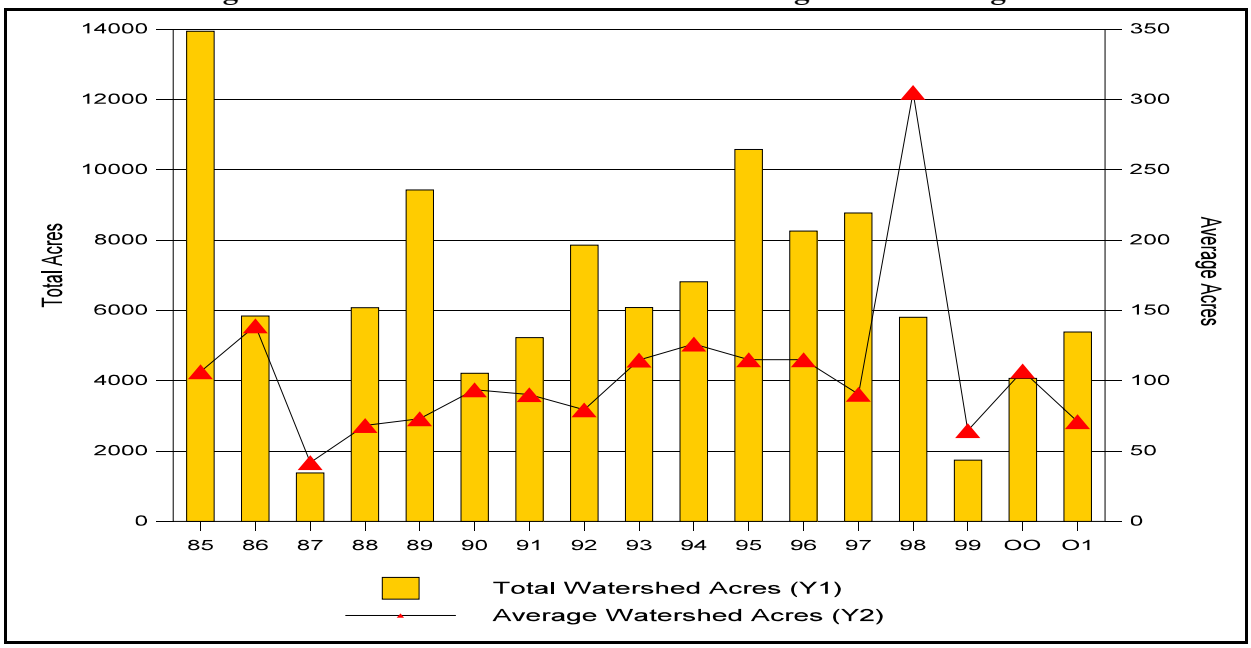


Table III.K-7 shows the distribution of watershed acres for valley fills approved in West Virginia for the period from 1985 through 2001. Fifty-nine percent of the valley fills approved have watersheds less than 75 acres. As the table shows, 73 valley fills have a watershed greater than 250 acres in West Virginia.

Table III.K-7
Distribution of Watershed Sizes for Valley Fills in West Virginia

Watershed Acres	Year																	Total
	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	
Less than 75 Acres	76	24	30	65	91	27	33	69	25	28	47	26	51	4	19	15	51	681
75 Acres to less than 250 Acres	44	14	3	22	33	15	20	25	24	20	35	32	42	8	7	23	26	393
250 Acres and Greater	11	4	0	2	5	3	5	5	4	6	10	6	4	7	1	0	0	73

5. Trends on Stream Impact Under Fill Footprints

The final measurement for evaluating impacts from valley fill construction and predicting their overall impact on the environment is stream loss. As discussed in III.K.2., the stream impact is based on a synthetic stream network defined on a 30-acre watershed accumulation threshold over the National Elevation Dataset (NED). The NED for each state was processed to enforce hydrologic integrity (filling of spurious sinks). A flow accumulation grid was prepared and queried to define a drainage network over the entire region. The stream network represents all drainage for watersheds greater than 30 acres. Table III.K.-8 provides a summary of trends on stream impacts by individual states within the study area.

Figure III.K-32 is the total length of stream impacts under the valley fill footprints approved in each of the states contained in the study area for the period from 1985 through 2001. The total of stream impact for states within the study area is 724 miles, or 1.23 percent of the 58,998 miles of streams within the study area.

Figure III.K-32 Trends in 30-Acre Synthetic Stream Impacts in States and Region

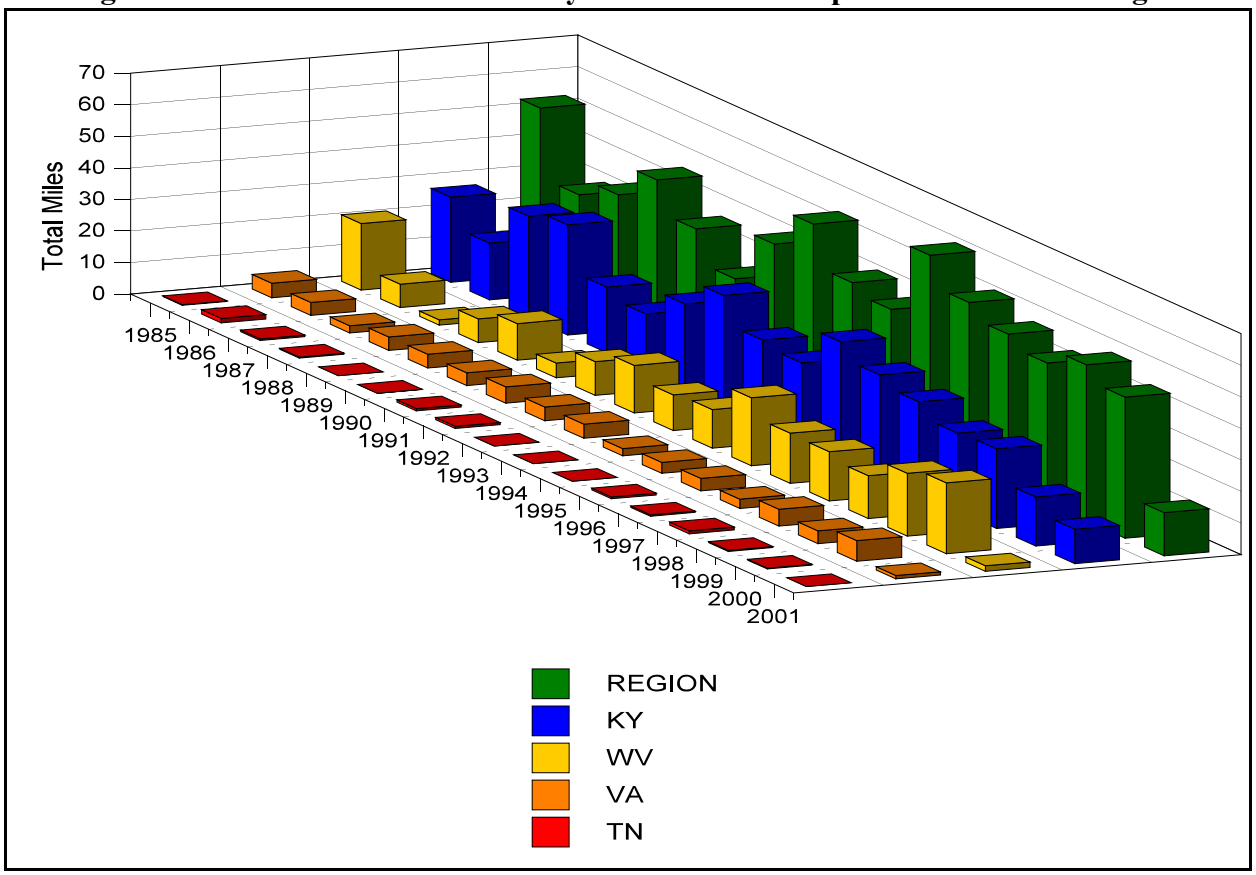


Table III.K-8
Yearly Totals by States for Impacts to Streams Under Valley Fill Footprints

Yr.	Stream Miles Under Valley Fill Footprints			
	KY	TN	VA	WVA
85	26.98	.22	4.6	21.02
86	18	1.42	4.04	7.39
87	32.07	.51	2.22	1.66
88	34.96	.33	4.27	7.55
89	20.81	0	4.32	11.66
90	17.85	.02	4.05	4.66
91	26.6	.65	5.16	10.73
92	34.9	.68	4.31	15.12
93	26.3	0	4.5	11.31
94	24.59	0	2.33	12.25
95	36.83	0	3.46	21.58
96	31.94	.58	4.01	15.91
97	28.99	.43	3	15.58
98	24.6	.92	5.36	13.55
99	25.19	.31	4.06	19.9
00	15.56	.24	6.58	22.41
01	10.19	0	1.09	1.73
Total	**436.36**	**6.31**	**67.36**	**214.01**

6. Relationship of Excess Spoil Generation to Mining Method

The gross volume of spoil generation on a given mine site is directly related to the total area of mining volume of overburden that is mined, and to the rock type of the overburden. Mining a given volume of sandstone would generate a larger volume of spoil than the same volume of shale regardless of mining method. Conceptually, mountaintop removal operations would generate the greatest volume of spoil on a given mine site, since that type of operation would remove all the overburden above the basal coal seam, typically at an overburden to coal or stripping ratio of approximately 15:1 (cubic yards overburden: ton of coal) in West Virginia. Total volume of excess spoil is related to the ability of the mine method and mine plan to return spoil to the bench. While mountaintop removal would normally be expected to generate the greatest volume of excess spoil on a given mine site, this is not always the case. An extensive (i.e., many linear feet or miles of contour cut) contour operation could generate more excess spoil (typical stripping ratio of 12:1 in southern WV) than a mountaintop removal operation on the same site because of bench spoil return restrictions imposed by maintaining sedimentation controls and haul roads along the croplines. The relationship of mining method to excess spoil disposal is therefore expected to be very site specific based on topography, overburden type, and extent of individual mining methods.

7. Relationship of Excess Spoil Generation to AOC Variance

To evaluate the possibility of a relationship between excess spoil generation and AOC variance status, several recent OSM Oversight Reports pertaining to AOC policies in the individual states were reviewed. In general, no definite relationship can be drawn from this information, largely due to differing policies regarding the need for AOC variances between the states and the lack of states achieving true AOC. However, it can be concluded that AOC variances would, inherently and by necessity, generally result in greater excess spoil volume in order to achieve a greater amount of flat land suited for alternative post-mining land uses. The following summarizes the findings for excess spoil disposal and AOC variance for each state.

a. Excess Spoil Generation and AOC Relationships in Kentucky

According to the 1999 OSM Oversight Report: "An Evaluation of Approximate Original Contour and Post-Mining Landuse in Kentucky," AOC variances were required to be requested by permit applicants if more than 20 percent of the original bank volume of the mine site's spoil was excess (i.e., to be placed in a fill). Under this policy, it would seem that permits with AOC variances would always have more excess spoil disposal than those that did not. However, Kentucky also required AOC variances for mine sites proposing to leave a permanent road, bench, terrace, or other feature exceeding 20 feet in width. Such circumstances could happen on any mine site whether fills were proposed or not, potentially skewing the results when included with sites that had variances for no reason other than excess spoil disposal. For this reason, no reliable relationship can be made between excess spoil disposal and AOC variance status in Kentucky.

b. Excess Spoil Generation and AOC Relationships in Tennessee

The limited number of permits that have been issued for excess spoil valley fills in Tennessee since 1988 (eight) allows a direct evaluation of the relationship for that state. Only one of the eight permits is reported to have had an AOC variance, and this permit proposed an excess spoil disposal of 24 percent. The remaining seven permits without AOC variance showed a proposed excess spoil disposal averaging 18 percent and ranging from 3 percent to 53 percent. Although the excess spoil disposal for the single variance permit was slightly higher than the average of the non-variance permits, it was still well within the range of the non-variance permits. This amount of data is too small for a definitive assessment of whether excess spoil disposal quantities are related to AOC variance in Tennessee.

c. Excess Spoil Generation and AOC Relationships in Virginia

The 1999 OSM Oversight Report "An evaluation of approximate original contour variances and post-mining land uses in Virginia" did not draw definite conclusions regarding a relationship between AOC variance and excess spoil generation. However, the report did state the following based on a sampling of Virginia mine permits: "Seventy percent of the permits in our sample proposed to place less material in fills than the predicted "swell" generated during mining. Due to the high percentage of remining sites in Virginia (80 percent of our sample), permittees' maintain most (83 percent) of the overburden generated during mining on the mine bench or on previously mined lands included within the permitted area. Because of the large amount of overburden retained on the mine benches and the overall configuration (including an average elevation change of -31' for AOC sites and -26' for variance sites) of the resulting land, one must question whether the majority of the sites in our study required a variance from approximate original contour restoration in the first place." From this it is inferred that most Virginia mines did not vary greatly in spoil disposal characteristics and reclamation practices between those with AOC variances and those without. Additional review of permit statistics would be required to verify that this is the case.

d. Excess Spoil Generation and AOC Relationships in West Virginia

The 1998 OSM Oversight Report: "Draft Report: An Evaluation of Approximate Original Contour and Post-mining Land Use in West Virginia"stated the following findings based on a sampling of West Virginia mine permit applications: "Where data was available, sites with AOC variances had a somewhat wider percentage range of excess spoil being placed in fills than did sites without AOC variances...the percentage of spoil being placed in fills ranged from 8 to 62 percent for sites with AOC variances and between 33 and 45 percent for sites without AOC variances. Both sites with and without AOC variances placed more material in the fill than could be accounted for by just the swell factor, which ranged from 20 to 40 percent, according to the permits...Current regulations do not place a numerical limit on the amount or percentage of material which may be placed in a fill..." An independent review of the OSM report data for this EIS did show the AOC variance sites to have a higher percentage of excess spoil disposal than those without variances, 45 percent compared to 40 percent. It is cautioned that this is a very limited sampling from which to draw any conclusions regarding a relationship between excess spoil disposal and AOC variance in West Virginia.

L. MINE FEASIBILITY EVALUATION AND PLANNING

The presence of coal reserves on a given site does not necessarily imply that the site can be economically mined. Evaluation of mining feasibility on any site requires a detailed investigation into the nature of the coal reserves and the physical, environmental, and regulatory constraints of the site. If a coal reserve is found to be conceptually feasible for mining, a mine plan must be developed to determine the actual economics and practical extent of the potential operation. Finally, the mine plan and attendant engineering and environmental controls must undergo regulatory scrutiny during the mine permitting process. This section provides an overview of the factors influencing mine feasibility and planning, and outlines the typical steps and considerations in developing a mine plan once a site has been determined to be feasible for mining. Figure III.L-1 provides a flowchart diagram of this overall process.

RETURN ON INVESTMENT AND PROFIT MAY NOT BE REALIZED UNTIL WELL INTO THE LIFE OF A MINE OR EVEN AFTER MINING IS COMPLETE WHEN RESIDUAL RECLAMATION BONDS HAVE BEEN RELEASED. THE DECISION TO PROCEED WITH A MINE SITE REPRESENTS A LONG-TERM COMMITMENT OF CAPITAL AND RESOURCES FOR A COAL COMPANY.

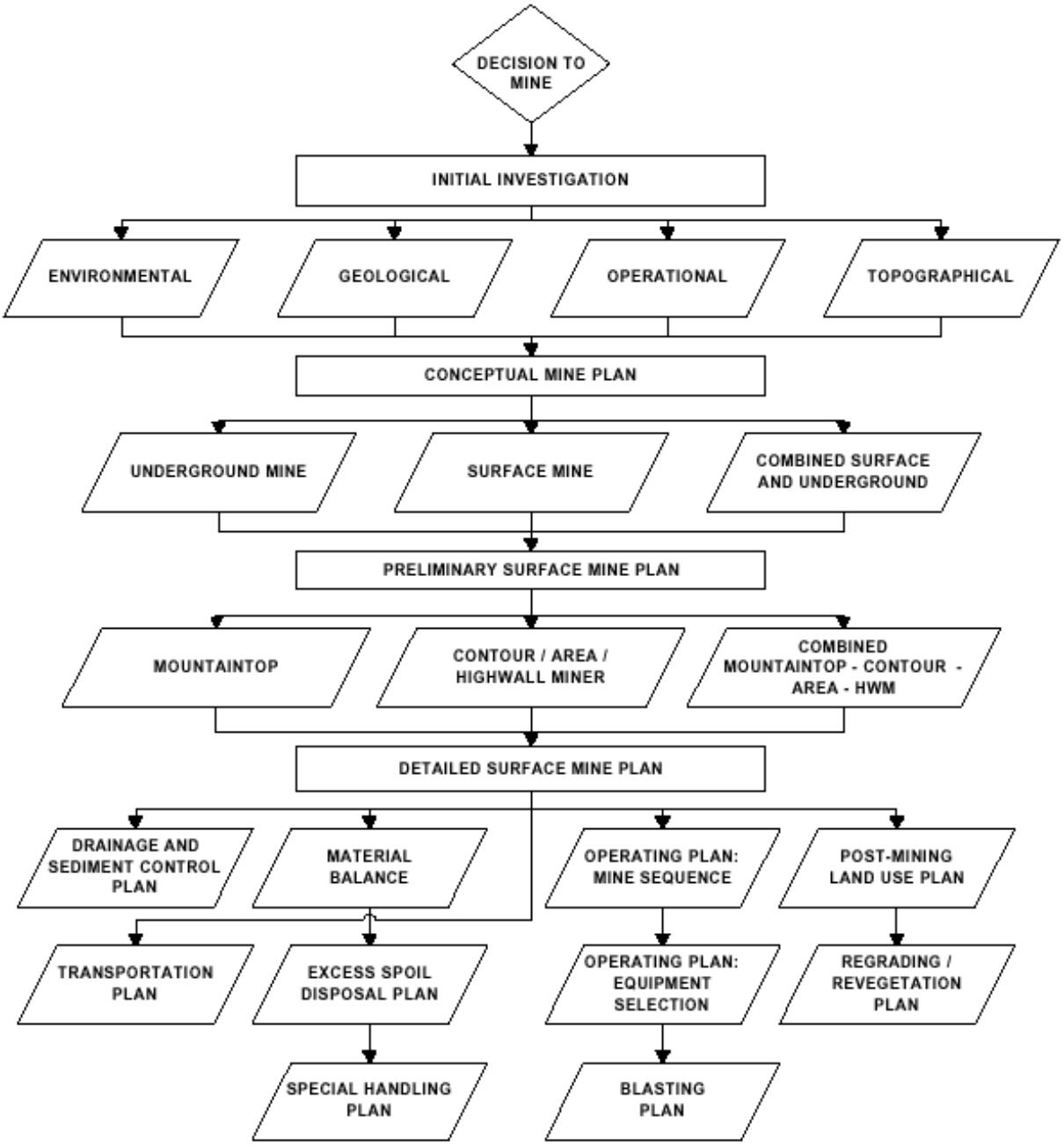
1. General Considerations

There are a number of economic and management factors that must be considered by a coal company before a decision is made to proceed with mine planning on a potential site. Mining in general requires a relatively high initial investment, with potential long-term delays in returns during the site planning, permitting, and development stages, and considerable risk due to fluctuations in market prices and production costs. Return on investment and profit may not be realized until well into the life of a mine or even after mining is complete, when residual reclamation bonds have been released and the mine site liquidated for other uses. The decision to proceed with a mine site, therefore, represents a long-term commitment of capital and resources for a coal company.

a. Property Ownership

To mine coal on a given piece of land, a coal company may already own the land, purchase the land outright, or lease the land from the landowner for mining purposes. Often, the mineral rights to the coal are owned separately from the surface property rights, and the coal company must negotiate with both parties for the right to mine. If a coal company does not own a property and/or attendant mineral rights, the typical arrangement is to pay the owners of these rights a royalty fee that can be based on the value or tonnage of coal mined. Royalty fees are established during the negotiation process for the mining rights. Other forms of mineral rights, such as oil and gas, may also conflict/compete with mining plans and need to be negotiated for protection or purchase. If a coal company owns or purchases a property for mining, it must consider the value that this land will represent after mining in determining the net cost of coal production. Coal mined from both owned

Figure III.L-1
Overall Mine Development Decision Process



Source: Miekle & Kitt, 1999

and leased land is also subject to a state (and sometimes local) severance tax--on top of royalties and production costs.

b. Capital Investment

Basic capital costs of mining include site development, equipment purchases, and on-site facilities. The costs to develop a site, such as haul road construction and utilities, may be partially offset by timber harvesting or recovered by postmining use of the land for residential, commercial, or industrial purposes. Some coal companies may lease mining equipment to avoid up-front capital expenditures, but most own their equipment. Large capital expenditure items, such as electric shovels and draglines, must normally be purchased outright. In general, investment in larger equipment reduces the cost per ton of production, but at the same time requires larger coal reserves and greater production rates (commensurate with the life of equipment) to justify the expenditure. Large mining operations may also invest in on-site coal processing plants and permanent structures for equipment maintenance and administration. These specialized facilities may be partially salvaged for use on other sites, but are otherwise not readily transferable for other postmining land uses.

c. Reclamation Bonding

Activation of a mine permit requires that reclamation bonds be posted on areas to be mined. The purpose of these bonds is to provide assurance that the coal operator will reclaim the mine site according to the approved reclamation plan, or to provide funds for the government to complete this work should a coal operator forfeit its responsibilities. SMCRA (30CFR 800.15) does not specify dollar amounts for bonding rates, other than requiring that no bond for a single permit be less than $10,000. Bond amounts, however, are based on a "worst-case" scenario based on the maximum amount of disturbed area open at any one time and may range from a few hundred thousand to many millions of dollars. The individual state regulatory authorities are responsible for establishing bonding rates that reflect the probable difficulty of reclamation, giving consideration to such factors as topography, geology, hydrology, structure and facility removal, and revegetation potential. The amount of the bond is intended to be sufficient to assure the completion of the reclamation plan if the work had to be performed by the regulatory authority in the event of forfeiture. Reclamation bonds are released in phases, with Phase 1 release occurring after backfilling and regrading have been completed on a given area, Phase 2 occurring after completion of revegetation activities, and the final Phase 3 release occurring after the mine site has been accepted as being satisfactorily reclaimed and the approved post-mining land use met (i.e., meets all performance standards and the approved permit plan). Complete release of reclamation bonds on a given area typically requires five years after completion of reclamation, and may be delayed further if satisfactory reclamation has not been achieved. Additional time may be required for attainment of certain post-mining land uses, such as commercial forest land. A coal company will usually post reclamation bonds through a bonding company, paying a percentage of the total bond as a fee, rather than making this outlay by itself. Larger companies post other types of sureties and collateral bonds with company assets at stake.

Virginia and West Virginia surface mining regulatory programs utilize approved alternative bonding systems.

In Virginia the reclamation bonding requirement may also be met by participation in the Virginia Coal Surface Mining Reclamation Fund (Pool Bond Fund). Participation in the Pool Bond Fund is optional for permittees. In order to qualify for participation in the Pool Bond Fund, a permittee must demonstrate to the VADMLR's satisfaction that they have at least a consecutive three-year history of compliance under the Act or any other comparable State or Federal Act. Participation in the Pool Bond Fund shall constitute an irrevocable commitment by the permittee to participate in regards to the applicable permit and for the duration of the coal surface mining operations covered by the permit.

An applicant filing a permit application which proposes to be pool bonded must pay an entrance fee prior to the issuance of the permit. The entrance fee is $5,000 when the total balance of the Fund is less than $1,750,000 and is $1,000 when the total Fund balance is greater than $2 million. A renewal fee of $1,000 is required of all permittees in the Fund at permit renewal.

Participants in the Virginia Pool Bond Fund must also post bond as follows:

(1) For those underground mining operations participating in the Fund prior to July 1, 1991, in the amount of $1,000 per acre covered by the permit. In no event shall the total bond be less than $40,000, except that on permits which have completed all mining and for which completion reports have been approved prior to July 1, 1991, the total bond shall not be less than $10,000.

(2) For underground mining operations entering the Fund on or after July 1, 1991, and for additional acreage bonded on or after July 1, 1991, the amount of $3,000 per acre. In no event shall the total bond for such underground operations entering the Fund on or after July 1, 1991, be less than $40,000.

(3) For all other coal surface mining operations participating in the Fund prior to July 1, 1991, the amount of $1,500 per acre covered by each permit. In no event shall such total bond be less than $100,000, except that on permits which have completed all mining and for which completion reports have been approved prior to July 1, 1991, the total bond shall not be less than $25,000.

(4) For other coal mining operations entering the Fund on or after July 1, 1991, and for additional acreage bonded on or after July 1, 1991, the amount of $3,000 per acre. In no event shall the total bond for such operations entering the Fund on or after July 1, 1991, be less than $100,000.

If a pool bond permit is placed into temporary cessation for more than six months, participants must post bond equal to the total estimated cost of reclamation for all portions of the permitted site which are in temporary cessation. The additional bond must remain in effect throughout the remainder of the period during which the site is in temporary cessation. At such time as the site returns to active status, the additional bond posted may be released.

Participants in the Pool Bond Fund must pay taxes according to the following schedule. At the end of any calendar quarter where the total balance of the Pool Bond Fund, including interest thereon, is less than $1,750,000, all permittees participating in the Pool Bond Fund shall pay within 30 days after the end of each taxable calendar quarter, an amount equal to the following.

(1) Four cents per clean ton of coal produced by the surface mining operation of the permit during the taxable calendar quarter.

(2) Three cents per clean ton of coal produced by the underground mining operation of the permit during the taxable calendar quarter.

(3) One and one-half cents per clean ton of coal processed or loaded by the preparation or loading facility operation of the permit during the taxable calendar quarter.

At the end of any calendar quarter where the total balance of the Pool Bond Fund, including interest thereon, exceeds $2 million, payments shall be deferred until the balance is less than $1,750,000 at the end of a quarter. No permittee is required to pay the reclamation tax on more than five million tons of coal produced per calendar year, regardless of the number of permits held by that permittee, except upon permit issuance the permittee must pay the applicable reclamation tax required on coal mined and removed under the permit during the one year period commencing with and running from the date of the commencement of coal production, processing or loading from that permit.

Permittees participating in the Pool Bond Fund and holding more than one type of permit are not required to pay a reclamation tax at a rate in excess of five and one-half cents per ton on coal originally surface mined by that permittee or in excess of four and one-half cents per ton on coal originally deep mined by that permittee. Permittees holding one permit upon which coal is both mined and processed or loaded are not required to pay more than the tax applicable to the surface mining operation or underground mining operation. However, the permittee must pay the one and one-half cents per clean ton for all coal processed and/or loaded at the permit which originated from other permits during the calendar quarter.

In West Virginia, the alternative bonding system requires a bond for each operation at the rate of $1,000 per acre (or fraction of an acre), with a minimum bond of $10,000. In order to supplement the amount of the bond provided by individual operators, the state established a special reclamation fund provided by taxes levied on the amount of coal produced by each operator. The amount of money in the fund can fluctuate between approximately one to two million dollars. The tax of one cent per ton is levied on each active mining operation. Monies contained in the fund are used for reclamation of areas where the bonds provided by individual operators are not sufficient to cover the actual costs of reclamation.

d. Coal Market Conditions

The market valuation of coal reserves is a critical factor in mine feasibility. The coal quality of reserves on a given property is also a significant determinant in a mine's ability to meet market needs. Many mines must recover particular seams of particular quality (often including blending of seams) to meet exacting contract specifications for coal with certain properties (e.g. heat value, as expressed in BTUs, or British Thermal Units, sulfur content, ash value, moisture content, etc.) for a specific use (i.e., steam coal for electrical generation, coking coal for steel making, etc.). Demand for coal and coal prices fluctuate due to a number of factors, including annual variations in weather patterns affecting heating and power generation, and costs of alternative fuels, such as petroleum. Coal companies will sometimes delay permitting of new mine sites or activation of existing permits if market conditions are not currently favorable for coal production. Production costs include labor, fuel and power, equipment maintenance, transportation, and administration and

engineering services. All of these costs are variable, depending on current economic conditions. Active mines are vulnerable to fluctuations in market prices and production costs because they cannot be simply idled for long periods of time. Capital payments on large pieces of mining equipment demand that they remain productive, and environmental regulations require that mine disturbances be reclaimed in a timely manner.

e. Permitting Requirements

Aside from the multitude of design and performance constraints stipulated by regulation, the most significant influence that permitting requirements have on mine planning is the time delay required between initiation of the permitting process and approval to mine. This may take a year or longer from the time of application submission, depending on the size and complexity of a mine site, and the nature and extent of its potential impacts on environmental resources. Mine planners must account for this delay in obtaining new reserves, such that production lags do not occur while waiting for a new permit to be approved. Since it is possible for a mine permit application to be denied during regulatory review, it is prudent to have approved permits in place prior to their need for activation. Mine permit applications are typically prepared for a coal company by an independent consultant, but some larger companies utilize in-house environmental and mining engineering staff.

Over time, the Corps has increased mitigation requirements on Section 404 CWA permits. The Corps strives for no net loss of aquatic functions. The requirement to avoid, minimize and then compensate for unavoidable impacts to waters of the United States has become a larger economic factor in the mining decision. Mine planners should account for the costs of mitigation associated with 404 permits. The use of stream assessment methods, which assess stream quality, can play a significant role in siting mining disturbances to avoid or minimize stream impacts. The methodology should be used early in mine planning to decide if higher quality streams can be avoided because the mitigation costs can be substantially higher than mitigation costs associated with highly degraded streams. Also, the potential for permit denial or a more lengthy permitting time-frame can result when impacts to high value aquatic resources are at stake. The reliance on compensatory mitigation to insure impacts are minimal on an individual and cumulative basis, will likely result in a greater need for financial assurances or bonding to guarantee mitigation is completed.

2. Site-Specific Considerations

Once a potential mine site has been identified and the general considerations for mining are found to be favorable, mine planners will begin to investigate the site in detail to determine whether mining is conceptually feasible. These background investigations provide the information necessary for most later planning stages. Figure III.L-1 summarizes the various avenues of investigation under four basic categories, as discussed in the following sections.

a. Geological

Of primary importance to mine planners are the numbers, extents, thicknesses, and qualities of coal seams present on a site. The process of determining these factors is called a *reserve evaluation*. Preliminary investigations can be conducted remotely using geological surveys and other records from previous mine operations. If the site warrants further investigation, an exploratory drilling

program is implemented to measure actual coal depths and thicknesses, record overburden types and properties, and secure samples for laboratory analysis. This information is not only necessary for a company to evaluate the economic feasibility of bringing a product to market or fulfill contract requirements, but is also required by SMCRA for permitting. The coal, overburden, surface and groundwater, and other features and properties must be sampled and analyzed at enough points throughout the proposed permit area to be representative of baseline conditions-and to allow prediction of mining impacts. Coal is analyzed for its quality factors, including sulfur, ash, moisture, and heat content, while overburden is analyzed for environmental and strength factors, including sulfur content, neutralization potential, geotechnical parameters, chemical and textural suitability as topsoil substitute, and slake durability. In general, the lower the ash and moisture content, and higher the heat content or BTU value, the higher the market value of the coal. Core samples are also recovered from coal seams to identify quality and quantity (thickness) changes and partings that may be present within individual seams and require special operational consideration.

A second important consideration during the reserve evaluation is the extent of previous mining. Aside from residual environmental consequences, such as acid mine drainage, former mine workings can render remaining coal reserves on a site uneconomical for recovery. Surface mining of former underground mines may be of marginal viability, as only a fraction of the original coal remains in place, as is the case with areas of previous highwall or auger mining. Former contour cuts from old surface operations may have also left remaining coal reserves under too great an overburden cover to be extracted by new surface methods. Alternately, the reclamation of abandoned previous mining may have a positive influence on the mine permitting process. Elimination of abandoned highwalls, daylighting of underground mines adversely impacting water quality, and extinguishing mine fires can all be viewed as environmental benefits of new operations on previously mined sites.

b. Topographical - Geographical

Topography and geography relate to the land forms of the mine site and its relationship to other environmental and cultural features in the vicinity. Most large mine sites now employ aerial photogrammetric mapping to develop accurate contour maps of potential mine sites. Results from reserve evaluation activities are then added to the site mapping to produce a three-dimensional database of site conditions. Areas surrounding the mine site are usually depicted using USGS topographic quadrangle maps-mechanically reproduced at a larger scale, typically 1 inch = 400 hundred feet. Geographic, environmental, demographic, and cultural features can then be added to the site map and spatially evaluated for their potential influence on mine planning. SMCRA requires that maps of this nature be submitted with permit applications. Maps, or cross-sections and profiles developed from these maps, must show such things as pre-mining slopes, geologic structure, surface and groundwater information, coal outcrops, access roads, diversions, mining cut sequences, location of toxic- and acid-forming overburden, well locations, nearby residents--just to name a few.

Primary topographic constraints within a mine site are slopes, degree of coal seam exposure, and availability of access, sediment control and excess spoil disposal sites. Geographic constraints include distance to public roads, coal processing facilities, coal shipping points, and electric utility service. Demographic factors include proximity to occupied buildings, property lines, workforce availability, municipal regulations, and taxes. Cultural resources, such as historical structures, cemeteries, Native American artifacts, and other sites of unique heritage may be present within a mine site and require special protection. Proximity to parks and other protected public lands also comes into consideration when evaluating the potential difficulties in permitting a given site.

c. Operational

Operational considerations relate to the mining methods and support requirements that may be practical for a prospective site. Foremost for steep-slope surface mining is the availability of excess spoil disposal areas in a practical geometry. Access routes for haul roads of an acceptable grade must also be present. Existing underground mines and gas wells may have to be avoided, particularly in the case of active operations.

Other important operational considerations are transportation distances for coal haulage and support materials. Transportation of coal is a significant percentage of its total production cost, and mine sites must be located within a reasonable distance of high-volume shipping points, such as railroads or barge loading facilities. Both large- and small-scale mining operations require access to petroleum fuel for equipment, although this is now largely satisfied by overland truck haulage and on-site storage. Large-scale mines may also require access to high-voltage electrical service to operate draglines, electric shovels, and other equipment. Running new high-voltage service to remote sites can represent a considerable expense, and such sites may be relegated to petroleum-fueled operations only.

3. MTM/VF Mine Economic Analysis

To provide a conceptual understanding of the economic factors associated with MTM/VF mine operations, this section summarizes an economic analysis for a typical large MTM/VF mine operation. This example is based on a case study of an actual mine operation in West Virginia, as presented by Meikle & Fincham (1999), and is an approximation of the typical MTM/VF mine characteristics outlined in the previous section. Operational statistics for the example mine site are presented in Table III.L-1. The following summarizes the mine site economics in terms of capital investment, employment, costs and earnings, taxes, and a comparison to the underground mining alternative. The ultimate return on investment for this mine was 9.6%.

a. Capital Investment

Capital investments are related to physical investment in a mine site and do not include the costs of day-to-day mine operation and maintenance. These investments are usually categorized for surface mine operations by heavy equipment, support equipment, and development costs. Individual investments required for the example mine under these categories are summarized in Tables III.L-2, III.L-3, and III.L-4, respectively. As these tables show, the majority of capital investment (about 70 percent) occurs during the first year of mine operation as the site is developed and equipment is purchased. Later capital investments are generally related to replacement of equipment over time. The total capital investment for the project is $58,345,000.

Table III.L-1
Example MTM/VF Mine Operational Statistics

Mine Statistic	Value	Units
Projected Mine Life	10	years
Total Coal Production	16,395,984	CT
Annual Coal Production	1,680,000	CT
Average Selling Price of Coal	$24.75	
Coal Tons per Man Hour	7.25	CT/MH
Mine Recovery Rate	80.36	%
Direct Shipping Percentage	80.00	%
Total Depth of Cut	436	feet
Number of Seams Mined	8	
Stripping Ratio	15.02	BCY/CT
Total Overburden Moved	246,283,400	BCY
Overburden Moved per Year	25,200,000	BCY
Total Overburden Haulage (70%)	172,398,380	BCY
Total Cast Blast and Dozing (30%)	73,885,020	BCY
Swell Factor	30	%
Total Spoil Generated	320,168,420	LCY
Spoil Returned to Mine Bench	192,101,051	LCY
Spoil Placed in Valley Fills	128,067,368	LCY
Spoil Return Percentage	60	%
Yards Overburden per Man Hour	108.90	BCY/MH
Total Man Hours Worked	2,261,507	MH

CT - clean tons BCY - bank cubic yards
MH - man hours LCY - loose cubic yards

Source: Meikle & Fincham, 1999

Table III.L-2
Example MTM/VF Mine Economic Analysis
Capital Budget - Life of Mine

HEAVY EQUIPMENT

Item Description	Year 0	Year 1	Years 2 thru 10	Total
25 Yard Shovel	$0	$3,500,000	$0	$3,500,000
18 ½ Yard Backhoe	$0	$2,650,000	$0	$2,650,000
16 Yard Endloader	$0	$1,200,000	$1,200,000	$2,400,000
210 Ton Rock Trucks	$0	$4,500,000	$0	$4,500,000
150 ton Rock Trucks	$0	$7,320,000	$0	$7,320,000
Fill Dozers	$0	$2,160,000	$1,050,000	$3,210,000
Development Dozers	$0	$1,440,000	$1,440,000	$2,880,000
Reclamation Dozers	$0	$720,000	$720,000	$1,440,000
45 Yard Dozers	$0	$4,800,000	$4,800,000	$9,600,000
16 Yard Coal Loader	$0	$2,400,000	$700,000	$3,100,000
9 Yard Coal Loader	$0	$1,100,000	$500,000	$1,600,000
Drills	$0	$2,400,000	$4,800,000	$7,200,000
Total	$0	$34,190,000	$15,210,000	$49,400,000

Source: Meikle & Fincham, 1999

Table III.L-3
Example MTM/VF Mine Economic Analysis
Capital Budget - Life of Mine

SUPPORT EQUIPMENT

Item Description	Year 0	Year 1	Years 2 thru 10	Total
Motor Grader	$0	$400,000	$0	$450,000
Water Truck	$0	$600,000	$0	$600,000
5 Yard Backhoe	$0	$300,000	$0	$300,000
Light Plants	$0	$150,000	$0	$150,000
Mechanics Trucks	$0	$520,000	$0	$520,000
Fuel Truck	$0	$130,000	$0	$130,000
Service Truck	$0	$260,000	$0	$260,000
Portal Trucks	$0	$75,000	$0	$75,000
Pick-Up Trucks	$0	$150,000	$300,000	$450,000
Total	$0	$2,635,000	$300,000	$2,935,000

Source: Meikle & Fincham, 1999

Table III.L-4
Example MTM/VF Mine Economic Analysis
Capital Budget - Life of Mine

CAPITAL DEVELOPMENT

Item Description	Year 0	Year 1	Years 2 thru 10	Total
Haul Road	$1,000,000	$0	$0	$1,000,000
Pond Construction	$500,000	$0	$1,000,000	$1,500,000
Stream Mitigation	$500,000	$0	$0	$500,000
Permitting Related	$500,000	$0	$0	$500,000
Exploration	$350,000	$0	$0	$350,000
Clearing & Grubbing	$460,000	$230,000	$920,000	$1,610,000
Office/Warehouse	$200,000	$0	$0	$200,000
Radio System	$50,000	$0	$0	$50,000
Pump System	$150,000	$0	$0	$150,000
Power & Phones	$150,000	$0	$0	$150,000
Total	$3,860,000	$230,000	$1,920,000	$6,010,000

Source: Meikle & Fincham, 1999

b. Employment

Table III.L-5 provides a detailed breakdown of the manpower allocation required for operation of the example MTM/VF mine site. The example site runs two 10-hour shifts per day, 5 days per week, for a total of 260 working days per year. A day shift with 47 employees and night shift with 42 employees combine for a total labor force of 89 employees working 231,400 man hours per year. Equipment operators are the majority of the labor force at 70 percent, with support technicians comprising about 20 percent, and supervisory staff making up the remaining 10 percent of the employees.

c. Costs and Earnings

The costs of mining coal at the example MTM/VF mine site are shown in relationship to the gross earnings for the sale of coal in Table III.L-6. Sale of coal at $24.75 per ton generates a gross revenue of $405,800,604. From this, the costs of marketing and transportation, overhead and reclamation, and production mining are subtracted, leaving a cash margin of $78,204,696. This equates to a production cost per ton of $19.98 and cash margin of $4.77 per ton. Deduction of capital depreciation and amortization leaves a net earning before interest and taxes of $26,513,450. Labor and supplies are the largest single cost category for coal production, about 60 percent of the total. Supplies and trucking costs together are about 44 percent of the total production cost. These two categories are largely dependent on fuel costs and are thus the most vulnerable to fluctuation over the life of the mine. The total direct wages and benefits earned by employees during the life of the mine are $83,796,596, and total service and supply expenditures for this period are $145,722,663.

Table III.L-7 provides a breakdown of the example mine's cash flow statistics over its operational life. Initial capital outlays and production costs result in a net operating loss of about $34,000,000 through the first year of mining. The return on this investment is not realized until the 8th year of mine operation. The rate of return on the investment is estimated at 9.60 percent.

d. Taxes

Coal mining is subject to a number of taxes on the federal, state, and sometimes local levels. For the example MTM/VF mine site, these add up to $58,073,684 over the life of the mine, equating to $3.54 per ton and representing 14 percent of its total market value. The coal severance tax is the largest component of the total tax burden at $1.24 per ton, or 35 percent of the total. Table III.L-8 lists the individual taxes to which the mine operation is subject by total mine life cost and cost per ton of coal.

Table III.L-5
Example MTM/VF Mine Economic Analysis
MANPOWER TABLE

Period: Full Year

Production Days = 260 days

C.T. Per M.H.		7.25
BCY Per M.H.		108.90

Manpower				Job Description	O.B. Production	# Prod. Days	Hrs. Per Day	Total Manhours
Position	Day	Evening	Total					
25 yd. Front Shovel	1	1	2	O.B. Loading	7,500,000	260	10	5,200
210 Ton Rock Truck	3	3	6	O.B. Haulage		260	10	15,600
Fill Dozer	1	1	2	Run Fill		260	10	5,200
18 ½ yd. Backhoe	1	1	2	O.B. Loading	5,800,000	260	10	5,200
150 Ton Rock Truck	3	3	6	O.B. Haulage		260	10	15,600
Fill Dozer	1	1	2	Run Fill		260	10	5,200
16 yd. Endloader	1	1	2	O.B. Loading	4,100.,000	260	10	5,200
150 Ton Rock Truck	2	2	4	O.B. Haulage		260	10	10,400
Fill Dozer	1	1	2	Run Fill		260	10	5,200
45 yd. Bull Dozer	4	4	8	Prod. Dozing	7,800,000	260	10	20,800
Development Dozer	2	2	4	Development		260	10	10,400
Reclamation Dozer	1	1	2	Reclamation		260	10	5,200
16 yd. Coal Loader	2	2	4	Coal Prep. Ldg.		260	10	10,400
9 yd. Coal Loader	2	2	4	Coal Prep. & Ldg.		260	10	10,400
Drillers	4	3	7	O.B. Drilling		260	10	18,200
Motor Grader	1	1	2	Road Maint.		260	10	5,200
Water Truck	1	1	2	Dust Control		260	10	5,200
Mechanics/Welders	2	6	8	Maintenance		260	10	20,800
P.M. Technicians	1	2	3	Maintenance		260	10	7,800
Fueler/Greaser	1	1	2	Maintenance		260	10	5,200
Blasters	6	0	6	Blasting		260	10	15,600
Blasting foreman	1	0	1	D & B Superv.		260	10	2,600
Prod. Foreman	1	1	2	Shift Superv.		260	10	5,200
Maint. Foreman	1	1	2	Maint. Superv.		260	10	5,200
Maint. Planner	1	1	2	Maint. Scheduling		260	10	5,200
Prod. Engineer	1	0	1	Engineering		260	10	2,600
Superintendant	1	0	1	General Superv.		260	10	2,600
Total	47	42	89		25,200,000			231,400

Source: Meikle & Fincham, 1999

Table III.L-6
Example MTM/VF Mine Economic Analysis of Earnings Before Interest and Taxes

	Total Project		
Parameter	**$$**	**$$ Per BCY**	**$$ Per C.T.**
Revenues	$405,800,604	$1.65	$24.75
Revenues Per ton	$24.75		
Non-Mining Costs:			
Sales Related Costs	$59,771,560	$0.24	$3.65
Intercompany Royalties	$0	$0.00	$0.00
Intercompany Commissions	$4,098,996	$0.02	$0.25
Trucking	$33,666,422	$0.14	$2.05
Other Transportation Costs	$9,837,593	$0.04	$0.60
Preparation Costs	$12,752,441	$0.05	$0.78
Subtotal	$120,127,012	$0.49	$7.33
Net Realization	$285,673,592	$1.16	$17.42
Indirect Costs:			
Overhead	$8,996,465	$0.04	$0.55
Reclamation	$2,459,394	$0.01	$0.15
Subtotal	$11,455,859	$0.05	$0.70
Mining Costs:			
Labor	$83,956,796	$0.34	$5.12
Supplies	$112,056,241	$0.45	$6.83
Subtotal	$196,013,037	$0.80	$11.95
Cash Margin	$78,204,696	$0.32	$4.77
Cash Margin Per Ton	$4.77		
Cash Cost Per Ton	$19.98		
Direct D.D. & A.	$51,691,246	$0.21	$3.15
Indirect D.D. & A.	$0	$0.00	$0.00
Subtotal	$51,691,246	$0.21	$3.15
Earnings Before Interest & Taxes (E.B.I.T.)	$26,513,450	$0.11	$1.62

Source: Meikle & Fincham, 1999

Table III.L-7
Example MTM/VF Mine Economic Analysis
CAPITAL INVESTMENT STATISTICS ($millions)

Parameter	Initial Inv. Year 0	Year #1	Year #2	Year #3	Year #4	Year #5	Year #6	Year #7	Year #8	Year #9	Year #10	Year #11
E.B.I.T.	$0.00	$2.43	$2.57	$2.64	$2.79	$2.82	$1.45	$1.55	$1.70	$5.22	$3.33	$0.00
Taxes @ 30%	$0.00	$0.73	$0.77	$0.79	$0.84	$0.85	$0.44	$0.47	$0.51	$1.57	$1.00	$0.00
Commissions	$0.00	$0.42	$0.42	$0.42	$0.42	$0.42	$0.42	$0.42	$0.42	$0.42	$0.32	$0.00
Taxes on Comm.	$0.00	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13	$0.10	$0.00
Intercompany Royalty	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Taxes on Intercompany	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Tax Savings Depl.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Net Income	$0.00	$2.09	$2.14	$2.14	$2.25	$2.27	$1.31	$1.38	$1.49	$3.95	$2.56	$0.00
(Add) DD&P	$0.00	$5.29	$5.29	$5.29	$5.22	$5.23	$6.53	$6.53	$6.48	$2.97	$2.85	$0.00
(Less) CapEx	$3.86	$37.06	$0.48	$0.23	$0.48	$2.78	$10.66	$1.70	$0.00	$2.55	$0.00	($6.65)
Net Cash Flow	($3.86)	($29.77)	$6.90	$7.21	$6.99	$4.72	($2.82)	$6.21	$7.97	$4.37	$5.41	$6.65

N.P.V. @ 5%	$7.45
N.P.V. @ 8%	$2.26
N.P.V. @ 10%	($0.52)
I.R.R.	9.60%
Payback Period	7.56 yrs

Cash Flows 1 - 11	
E.B.I.T.	$26.51
Net Inc.	$21.43
Net Cash	$19.98

Source: Meikle & Fincham, 1999

Table III.L-8
Individual Taxes
By Total Mine Life Cost and Cost Per Ton of Coal

Taxes	Total Mine Life Cost	Cost Per Ton of Coal
Personal Property Tax	$3,132,574	$0.19 per ton
Worker's Compensation	$5,559,085	$0.34 per ton
Matching FICA	$3,097,378	$0.19 per ton
Unmined Mineral Tax	$1,173,000	$0.07 per ton
Franchise Tax	$504,390	$0.03 per ton
Severance Tax	$20,290,033	$1.24 per ton
Black Lung Tax	$8,747,264	$0.53 per ton
Federal Reclamation Tax	$5,566,431	$0.34 per ton
WV Special Assessment	$819,798	$0.05 per ton
Federal & State Income Tax	$9,183,734	$0.56 per ton
TOTAL	**$58,073,684**	**$3.54 per ton**

Individual taxes and tax rates vary between states in the study area. It is predicted that total taxes would be $4,189,994 less if this same operation where conducted in Kentucky, and $12,187,134 less if it were conducted in Virginia.

4. Mining Method Considerations

Selection of the appropriate mining method(s) for a given site is a complicated, iterative process during the mine feasibility evaluation and planning stages. Choices are typically driven by the desire to maximize coal recovery with the least expensive mining method that is practical for a given coal seam. This section summarizes the basic considerations for mine method selection.

a. Mine Method Selection Factors

The two basic options in mine method selection are surface and underground mining, or a combination of the two. For surface operations, contour, area, and mountaintop removal methods are available individually or in combination, and room and pillar and/or longwall mining are available for underground operations. The primary factors used for deciding between the individual methods are summarized in Table III.L-9.

Table III.L-9
Summary of Mine Method Selection Factors

Selection Factor	Surface Methods			Underground Methods	
	Contour	Area	Mountaintop Removal	Room & Pillar	Longwall
Coal Seam Thickness	≈ 1 ft	≈ 1 ft	≈ 1 ft	>= 28 in	>= 6 ft
Stripping Ratio	≈ 10 - 12	≈ 12 - 15	≈ 15 - 20	NA	NA
Maximum Cover	varies - 100	varies -	varies -	≈ 1,500 ft	> 1,500 ft
Minimum Cover	NA	NA	NA	100 ft	> 100 ft
Reserve Size	L - M	M - H	H	L - M	H
Recovery Rate	varies	< 100%	up to 100%	40 to 80 %	up to 85%
Excess Spoil Generation	L - M	M - H	M - H	NA	NA
Capital Investment	L	M - H	H	L - M	H
Equipment Size	L	M - H	H	L - M	H
Mine Plan Flexibility	M - H	L - M	L	M - H	L
Orphan Reserves	M	L	NA	M - H	L - M

Relative value for comparison: L - Low, M - Moderate, H - High, NA - Not Applicable
Source: Gannett Fleming, Inc.

When dividing a reserve between surface and underground mining methods, stripping ratios may be first applied to determine which seams are impractically deep for surface mining. Lower seams meeting the thickness and cover criteria for either of the two underground methods may then be considered for underground operations. The upper seams are examined more closely to refine their applicable surface mining methods. The maximum practical extent of contour mining may first be delineated for each seam by its stripping ratio. Remaining interior cores of ridges or mountaintops are then evaluated to determine how far mining can progress using stripping ratios generated by multiple-seam area or mountaintop removal approaches. Thus, more than one mining method may be applied on a given site.

Application extent for individual mining methods may be further constrained by site factors not related to stripping ratio alone, such as a reserve size being too small to justify heavy-equipment mining methods. Extent of mining can be limited by availability of excess spoil disposal volume, favoring contour mining over area or mountaintop removal methods. Site geometry of topography and coal seams may be incompatible with the capabilities of equipment spreads, leading operations to become "spoil bound," or not having sufficient space to maneuver and place spoil. The equipment or capital investment capabilities of an operator may also dictate a lesser extent of mining than conceptually feasible. Mine plan flexibility becomes a consideration for marginal operations under unstable market conditions. A final important consideration is generation of orphan reserves, or those that will be left permanently unmineable due to high stripping ratios after completion of mining. Evaluation of feasibility of highwall mining to partially recover these reserves requires consideration of lengths of time that pits must remain open and their extent as this relates to backfilling of spoil from other working areas of the mine.

M. COAL DISTRIBUTION AND MARKETS

1. Coal Uses and Distribution

The Energy Information Administration (EIA) develops and publishes energy market projections. The projections are "business-as-usual trend forecasts, given known technology, technological and demographic trends, and current laws and regulations" (USDOE EIA, 2000). Selected EIA coal related projections from the *Annual Energy Outlook, 1999* (USDOE EIA, 2000) are presented in this sub section and the ones that follow.

Nationally, the predominant use of coal is for electricity generation. Coal use in electricity generation has grown and is projected to continue growing. The combined other uses of coal have fallen since at least 1970 and are projected to increase only very slightly. [Figure III.M-1 Electricity and Other Coal Consumption, 1970-2020]

Figure III.M-1

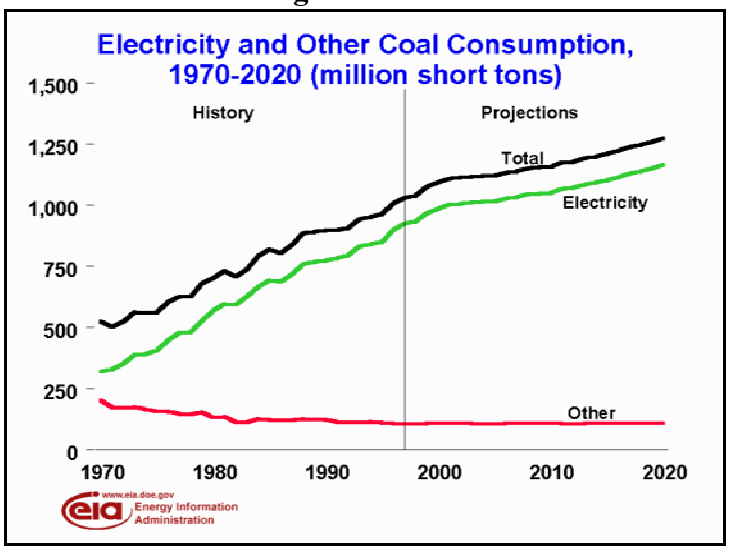


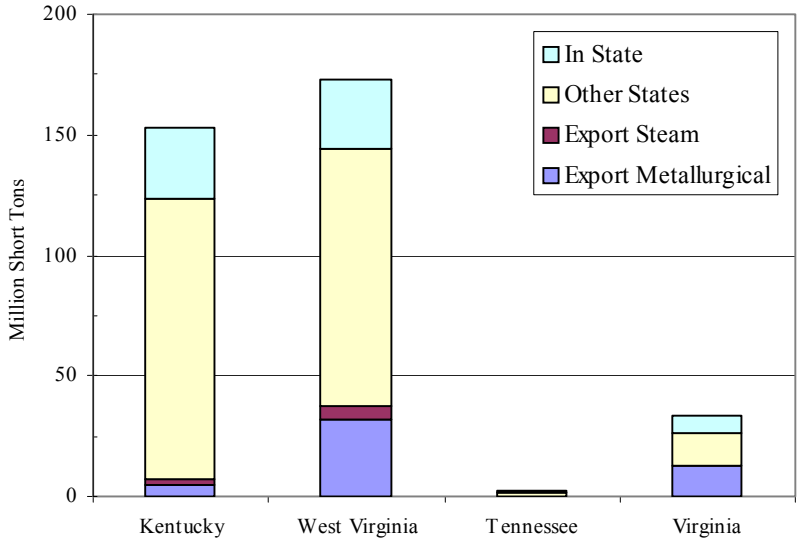
Table III.M-1 and Figure III.M-2 display the distribution of coal produced in the study area states in 1998. West Virginia is the leading exporter of U.S. coal. Its exports of 37.5 million short tons represent 47 percent of total foreign distributions in 1998. Twenty-two percent of West Virginia's 1998 coal production was exported. Metallurgical coal is the state's dominant export, comprising 86 percent of West Virginia's coal exports.

Table III.M-1
Coal Distribution, 1998
(million short tons)

Destination	Producing State				Percent of Total Production			
	KY	WV	TN	VA	KY	WV	TN	VA
Export Metallurgical	5.0	32.2	—	12.6	3%	19%	0%	37%
Export Steam	1.9	5.3	—	0.2	1%	3%	0%	.5%
Other States	116.5	106.6	1.3	13.1	78%	62%	48%	39%
In State	29.7	28.5	1.4	7.6	20%	17%	52%	23%

Source: U.S. Department of Energy, Energy Information Administration., 2000. *Coal Industry Annual, 1998.*

Figure III.M-2
Coal Distribution, 1998



Source: U.S. Department of Energy, Energy Information Administration, 2000. Coal Industry Annual, 1998.

While Virginia's output is much smaller than that of West Virginia, exports figure even more prominently in its coal distribution patterns. Nearly 38 percent of its 1998 production was exported; the great majority of this being metallurgical coal. Tennessee recorded no coal exports in 1998. Kentucky exported four percent of its 1998 production, about three-quarters of it as metallurgical coal. Kentucky's steam coal exports have fallen considerably from their five year high at 6,055

thousand short tons in 1995 to 1,889 thousand short tons in 1998. Kentucky metallurgical coal exports in 1998 are roughly unchanged from 1993 levels.

2. Productivity and Price Trends

One of the most noteworthy trends of the past decade of coal mining is the increase in labor productivity. Gains in coal mine labor productivity result from technology improvements, economies of scale, and better mine design. Improvements in labor productivity have been, and are expected to remain, the key to lower coal mining costs. Labor productivity, measured as short tons of coal, per miner, per hour, has improved as shown in Table III.M-2 below:

Table III.M-2
Coal Mining Productivity (short tons per miner per hour)

Region	1998		1989		Avg. Annual % Change	
	Under-ground	Surface Mines	Under-ground	Surface Mines	Under-ground	Surface Mines
Eastern Kentucky	3.28	4.27	2.40	2.92	3.5	4.3
So. West Virginia	3.89	5.74	2.57	3.71	4.7	5.0
Tennessee	2.25	2.90	1.58	2.20	4.0	3.1
Virginia	2.56	3.54	2.15	2.59	2.0	3.6
Wyoming	10.09	39.79	3.21	21.38	13.6	7.1

Source: U.S. Department of Energy, Energy Information Administration, 2000. Coal Industry Annual, 1998.

The table illustrates impressive gains in productivity in the study area and also illustrates Wyoming as an example of western coal productivity. The gains in Wyoming (the largest coal-producing state in the U.S.) and the vastly higher productivity in that state relative to the Appalachian coalfields are noteworthy because of increasing competitive pressure from western coal. Wyoming coal miners enjoy extraordinarily thick seams that lie close to the earth's surface. The higher labor productivity in surface mining compared to underground mining reflects the inherently greater labor intensity of underground mining.

On a national average, the share of wages in minemouth prices was 31 percent in 1970 and has fallen to 17 percent in 1998. The EIA projects that continued improvements in mine productivity (averaging 6.2 percent a year since 1977) will cause falling real mine prices throughout the forecast.

Figure III.M-3 Coal Mining Labor Productivity by Region 1990-2020 (short tons per miner per hour), displays the increasing labor productivity in the recent past and over the forecast period and contrasts the high productivity western coalfields with those of the eastern U.S.
Table III.M-3 illustrates the relative minemouth prices among regions and the fall in prices over the period 1989-1998. The table illustrates the higher price of underground mined coal versus surface mined coal. It also illustrates the considerably lower minemouth price of western coal (that pulls down the national average price) and the greater declines in western coal prices compared to that

of the study area. Figure III.M-4 Average Minemouth Price of Coal by Region, 1990-2020 (1997 dollars per ton), depicts the historic and projected trends for falling minemouth prices in both eastern and western coalfields. It should be noted here that coal consumers are considering other factors besides mine month price, including coal quality and transportation costs.

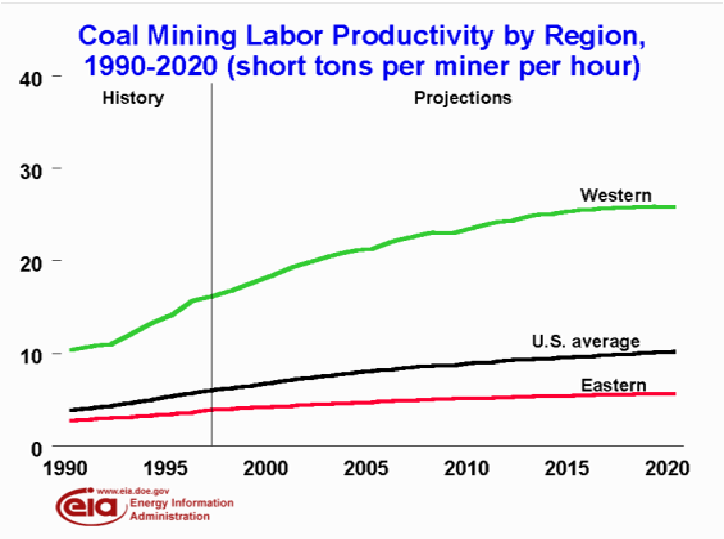
Table III.M-3
Average Mine Price ($ per short ton)

Region	Price in 1998			1989-1998
	Underground	Surface	Average	Avg. Annual % Change
Eastern Kentucky	$25.36	$23.57	$24.59	-0.5
Southern West Virginia	$29.28	$24.79	$27.57	-0.6
Tennessee	w	w	$28.69	0.7
Virginia	$29.55	$26.21	$28.69	0.4
Western U.S.	$17.58	$7.77	$8.76	-3.5
United States	$25.64	$12.92	$17.67	-2.3

Source: U.S. Department of Energy, Energy Information Administration, 2000. *Coal Industry Annual, 1998.*

In addition to falling minemouth prices, coal transportation costs are projected to fall, resulting in lower utility prices for coal. Falling coal prices are projected to continue contributing to decreased costs at coal fired power plants. Since 1980, the per-kilowatt-hour fuel costs for coal fired power plants have fallen significantly. Fuel prices have been declining since the early 1980s. Generating costs for coal fired plants decreased by 49 percent from 1980 to 1996. In addition, non-fuel operations and maintenance costs are also expected to fall. Efforts to cut staff and reduce operating costs were prompted by the combination of technology improvements and competitive pressure. The amount by which utilities can continue to cut costs is uncertain, but many analysts agree that further reductions are possible (USDOE EIA, 2000).

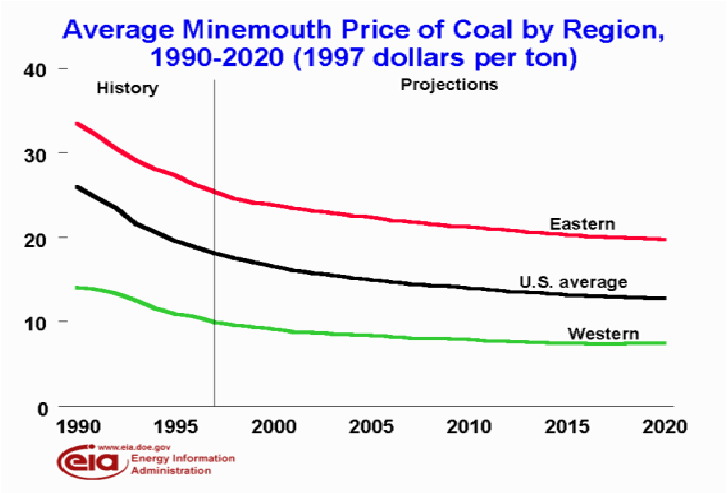
Figure III.M-3



3. Coal Demand and Production Projections

The lower projected coal prices, combined with projected increases in electricity demand, would create increasing demand for coal. This coal demand is subject to a fixed sulfur emissions cap from the Clean Air Act Amendments of 1990, which mandate progressively greater reliance on the lowest sulfur coals (from Wyoming, Montana, Colorado, and Utah). As coal demand grows, however, new coal fired generating capacity is required to use the best available control technology: scrubbers or advanced coal technologies that can reduce sulfur emissions by 90 percent or more. Thus, even as the demand for low sulfur coal grows, EIA predicts that there will still be a market for low cost higher sulfur coal throughout the forecast. From 1997 to 2020, EIA projects high and medium sulfur coal production to increase from 654 to 662 million tons annually (0.1 percent a year), and low sulfur

Figure III.M-4



coal production to increase from 445 to 696 million tons annually (2.0 percent a year). As a result of the competition between low sulfur coal and post-combustion sulfur removal, western coal production is projected to continue its historic growth, reaching 772 million tons in 2020. Its growth rate, however, is projected to fall from the 9.4 percent average annual growth achieved between 1970 and 1997 to 1.8 percent average annual growth in the forecast period (USDOE EIA, 1998)

The EIA projects competition from very low sulfur, low cost western and imported coals to limit the growth of eastern low sulfur coal mining. Western low sulfur coal has been successfully tested in all U.S. Census divisions, except New England and the Mid-Atlantic, and its penetration of eastern markets is projected to increase (USDOE EIA, 1998). Projected falling transportation costs are expected to reinforce this trend. The recent history and projected production from eastern and western coal sources is depicted in Figure III.M-5 Coal Production by Region, 1970-2020 (million short tons). The EIA projects that the western production will increase considerably while eastern production remains essentially flat. As for coal exports, EIA projects slow growth for total U.S. coal exports and a slight decline in metallurgical coal exports.

THE EIA PROJECTS COMPETITION FROM VERY LOW SULFUR, LOW COST WESTERN AND IMPORTED COALS TO LIMIT THE GROWTH OF EASTERN LOW SULFUR COAL MINING.

4. Structure of the Coal Industry [1]

During the past decade, the coal industry, often in response to market forces, has undergone major structural changes. The depressed coal market since 1984 and the Clean Air Act Amendments of 1990 (CAAA) induced changes in coal demand patterns that have resulted in (1) the coal industry being increasingly concentrated in ownership and (2) the transformation of coal companies from local and regional companies into nationally based companies.

THE DEPRESSED COAL MARKET SINCE 1984 AND THE CLEAN AIR ACT AMENDMENTS OF 1990 INDUCED CHANGES IN COAL DEMAND PATTERNS THAT HAVE RESULTED IN (1) THE COAL INDUSTRY BEING INCREASINGLY CONCENTRATED IN OWNERSHIP AND (2) THE TRANSFORMATION OF COAL COMPANIES FROM LOCAL AND REGIONAL COMPANIES INTO NATIONALLY BASED COMPANIES.

A lower than expected level of demand for coal has contributed to chronic excess production problems for the coal industry. According to the EIA, the average price for coal at minemouth (in constant dollars) has declined since 1975 and is at a level similar to that in 1970—the pre-oil embargo era (USDOE EIA, 1998). In recent years, some coal producers were reportedly forced to price their products at or below variable costs in order to sell them (DRI/McGraw-Hill). Many marginal coal operations were forced to shut down.

Previously, companies that sold most of their coal under long term contracts could use the profits on these contracts to subsidize spot market sales at prices below average total costs. Most coal contracts include a market reopener clause to allow coal buyers or sellers to renegotiate if the contract price proves to be higher than the market price for similar coals by a predetermined amount. This price mechanism is used to prevent the contract price of coal from escalating too rapidly. However, in a sustained downward market, the market reopener clause in coal contracts has enabled the price of coal to approach the cost of *incremental* production (i.e., the marginal cost) and not the fully loaded cost that includes capital recovery. In such an environment coal producers must become much more efficient so that the cost of production could be lowered.

Another aspect of the changing landscape of the coal industry has been the entry and subsequent exit of oil producers. Many oil companies diversified into the coal business in the 1970's with the expectation of a high return on their investments. The depressed coal price levels and the changing investment environment contributed to the exit of major oil companies from the coal business during the past 5 years. Consequently, many coal properties have changed hands.

Falling coal prices, tight profit margins, and a changing business environment have resulted in a surge of coal industry consolidation and merger activities. The vast majority of the acquisitions during the past 5 years have involved low sulfur or compliance coal properties. While oil companies exited from the coal business, traditional mining companies expanded their coal holdings. Company buyouts and mergers such as Amax and Cypress, Consolidation Coal and Island Creek, and Kennecott's buyout of NERCO and Sun's coal properties have transformed local and regional coal companies into nationwide companies. Since 1982, the coal industry has become much more

[1] The discussion in this section is from the "*Final Economic Analysis of Valid Existing Rights*", U.S. Department of Interior, 1999.

concentrated. In 1982, the top 10 companies accounted for 34 percent of the total U.S. coal production. By 1993, production from the top 10 companies accounted for approximately 45 percent of the total. The continuing coal industry concentration will result in fewer and larger coal suppliers.

The changing business environment brought about by the CAAA and, subsequently, by the deregulation of the electric utility industry mandated by the Energy Policy Act of 1992 has caused the coal companies to reevaluate their long term business strategies. The quality of coal demanded at electric utilities, the largest customers of coal, has changed as electric utilities move from Phase I CAAA compliance in 1995 to Phase II compliance by 2000. In order to survive or to expand their market shares, coal companies will have to be flexible in offering a wide range of products with coal quality varying from high sulfur to low sulfur. Major coal companies are expanding or acquiring coal properties in areas where they did not previously have a presence. As a result, the coal business has become much more national and in some cases even global.

With the exception of only a few short periods in history, the coal industry has otherwise been characterized by overcapacity. The chronic supply/demand imbalance, the dynamics of the coal market, and the relative ease of entry into the coal business have contributed to the competitiveness of the industry. Since the passage of the CAAA, coal market competition intensified. In addition to competition among coal operators in terms of mining methods, geographic locations, and coal qualities, coal must compete with natural gas, foreign coals, and SO_2 emissions allowances. The intensity of competition in today's coal market is unprecedented.

Another trend in coal mining is one towards larger mines. Increasingly complex permitting requirements and the large machinery investments required of modern high productivity mining methods make for high fixed costs. These high fixed costs require high volume production to achieve profitable unit costs.

THE HIGH FIXED COSTS OF MODERN COAL MINING REQUIRE HIGH PRODUCTION VOLUMES TO ACHIEVE PROFITABLE UNIT COSTS.

In West Virginia for example, the largest 22 mines (of 35 total), all produced more than 500,000 tons/yr and jointly accounted for 96 percent of state coal production. Virginia has 52 coal mines, but the largest five produce more than 300,000 tons/yr (Directory of Mines 1998) and account for 92 percent of state coal production (VA DMME 1998). In Kentucky, the largest 49 of 195 total mines produce more than 300,000 tons/yr and account for 68 percent of state coal production (VA DMME 1998).

N. PAST AND CURRENT MINING IN THE STUDY AREA

Coal production within the steep slope areas of West Virginia, Kentucky and Virginia closely follows the historical trend of the overall United States coal mining industry. In general, coal production in the United States increased annually due to increased mechanization of the industry from 1890 to the great depression of the 1930s, when production dropped off significantly. Coal production began to increase again with the onset of World War II and continued increasing until after the Korean conflict. In 1954, the railroad industry's conversion from coal to diesel fuel brought a modern low point in coal production. Since then, annual coal production has generally increased or remained stable.

Tables III.N-1, III.N-2 and Figure III.N-1 present data on coal production for the study area, using data from the Energy Information Administration (EIA). The discussion below highlights some of the notable statistics contained in these tables. The EIA data do not distinguish among the different types of surface mining methods. Based on research conducted by Hill and Associates (2000) and by Resource Technologies Corporation (2000), roughly 95 percent of the surface mining in southern West Virginia would be classified as the MTM/VF mining that is the subject of this EIS. The proportions for eastern Kentucky, Virginia, and Tennessee are not known.

Table III.N-1
Coal Production Trends by State, Region, and U.S. (Thousand Short Tons)

Coal-Producing State and Region	1989	1994	1998	Avg. Annual Percent Change	
				1994-1998	1989-1998
Kentucky Total	167,389	161,642	150,295	-1.8	-1.2
Eastern	125,739	124,447	116,654	-1.6	-.8
Western	41,649	37,195	33,641	-2.5	-2.3
Tennessee	6,480	2,987	2,696	-2.5	-9.3
Virginia	43,006	37,129	33,747	-2.3	-2.6
West Virginia Total	153,580	161,776	171,145	1.4	1.2
Northern	56,018	49,316	44,618	-2.5	-2.5
Southern	97,562	112,460	126,527	3.0	2.9
Study Area Total	272,787	277,023	279,624	0.2	0.3
State Totals	370,455	363,534	357,883	-0.4	-0.4
U.S. Total	980,729	1,033,504	1,117,535	2.0	1.5

Source: Energy Information Administration. 2000 - http://www.eia.doe-gov/cneaf/coal/cia/special/t1p01p1.html

Southern West Virginia is the only portion of the study area to have experienced higher coal production in 1994 and 1998 than in 1989.

Figure III.N-1
Coal Production, 1998

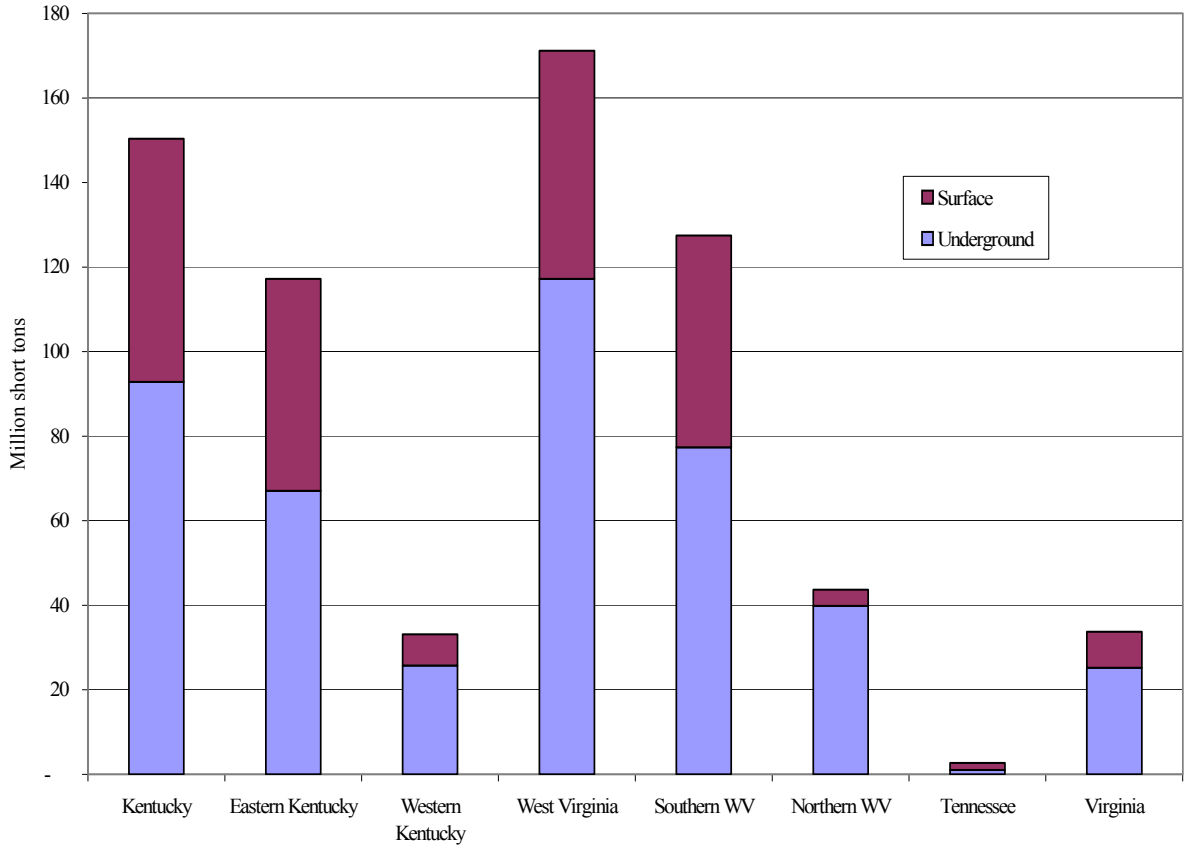


Table III.N-2
Coal Production and Number of Mines by State, County, and Mine Type, 1998 (thousand short tons)

Location	Underground		Surface		Total	
	Mines	Production	Mines	Production	Mines	Production
Kentucky	277	92,832	205	57,462	482	150,295
Eastern Tier	**259**	**67,066**	**186**	**49,589**	**445**	**116,654**
Bell	12	3,390	10	2,130	22	5,520
Breathitt	–	–	5	4,302	5	4,302
Clay	1	25	5	348	6	373
Floyd	31	2,426	8	3,258	39	5,684
Harlan	29	6,629	10	1,502	39	8,131
Jackson*	–	–	1	3	1	3
Johnson	3	1,100	3	37	6	1,137
Knott	25	5,119	19	3,943	44	9,061
Knox	11	399	6	188	17	587
Lawrence	1	145	4	130	5	275
Leslie	8	7,470	7	2,167	15	9,637
Letcher	15	6,519	23	3,342	38	9,860
Magoffin	–	–	2	819	2	819
Martin	24	6,530	11	5,048	35	11,578
Owsley	–	–	3	50	3	50
Perry	14	5,755	17	8,729	31	14,484
Pike	82	21,420	49	13,470	131	34,890
Whitley	3	139	3	125	6	264
Tennessee	**13**	**1,047**	**14**	**1,649**	**27**	**2,696**
Anderson	2	16	–	–	2	16
Campbell	2	470	5	382	10	852
Claiborne	4	503	4	435	8	937
Cumberland	–	–	1	86	1	86
Fentress	–	–	2	211	2	211
Morgan	1	11	–	–	1	11
Scott	1	47	–	–	1	47
Sequatchie	–	–	2	537	2	537

Table III.N-2
Coal Production and Number of Mines by State, County, and Mine Type, 1998 (thousand short tons)
(Continued)

Location	Underground		Surface		Total	
	Mines	Production	Mines	Production	Mines	Production
Virginia	**127**	**25,212**	**46**	**8,535**	**173**	**33,747**
Allegheny	–	–	1	109	1	109
Buchanan	55	10,941	9	1,537	64	12,477
Dickenson	14	2,271	8	971	22	3,242
Lee	5	1,057	2	169	7	1,225
Russell	6	809	2	415	8	1,224
Tazewell	12	1,807	–	–	12	1,807
Wise	35	8,327	24	5,335	59	13,662
West Virginia	**246**	**117,191**	**100**	**53,955**	**346**	**171,145**
Southern Tier	**213**	**77,954**	**73**	**48,572**	**286**	**126,527**
Boone	30	21,066	8	8,420	38	29,486
Braxton	1	588	–	–	1	588
Clay	–	–	4	6,636	4	6,636
Fayette	3	1,358	4	1,993	7	3,351
Greenbrier	2	496	3	30	5	526
Kanawha	10	4,647	6	9,478	16	14,126
Lewis	–	–	1	1	1	1
Lincoln	1	24	–	–	1	24
Logan	21	3,814	8	10,305	29	14,119
McDowell	63	4,4343	10	1,901	73	6,244
Mingo	27	16,160	14	6,249	41	22,409
Nicholas	6	2,015	4	749	10	2,764
Raleigh	20	12,376	2	109	22	12,486
Wayne	4	3,366	2	1,024	6	4,390
Webster	5	2,147	2	2,586	7	4,733
Wyoming	20	8,289	5	1,679	25	9,967

*Surface Production rounded to zero

Source: Energy Information Administration, 2000. htp:www.eia.doe.gov/cneaf/coal/cia/special/tb104p01.txt

1. Kentucky

Kentucky had the third highest state coal production rate in 1998. The 150.3 million short tons produced in Kentucky comprised over 13 percent of the domestic coal production (Table III.N.-1). Eastern Kentucky is the dominant of the state's two coal mining regions, producing 117.2 million short tons in 1998, or 78 percent of the total state production. Production in eastern Kentucky has decreased at an average annual rate of -0.8 percent from 1989 to 1998. Production in western Kentucky has also decreased, resulting in a slight net decrease (-1.2 percent) for the state overall over the period. The four eastern Kentucky counties of Pike, Martin, Letcher, and Perry account for 47 percent of the total state production (Table III.N.-2). In 1998, the top producing mine in the state was Lodestar Energy's No. 13 Baker underground mine, with 4.39 million short tons of coal.

SURFACE MINING ACCOUNTS FOR 42.5 PERCENT OF THE COAL PRODUCTION IN EASTERN KENTUCY IN 1998. THE TOP SURFACE MINING COUNTIES IN 1998 WERE PIKE, PERRY, AND MARTIN

In 1998, eastern Kentucky surface coal mines produced 49.6 million short tons from 186 mines (Table III.N.-2), that accounted for 33 percent of the total state coal production and 42.5 percent of eastern Kentucky production. Eastern Kentucky had 259 operating underground mines in 1998, producing 67 million short tons of coal. Coal production from Kentucky underground mines has increased less than 1 percent annually from 1988 to 1997. The continuous mining method produces the majority (74.9 million short tons) of coal mined by underground methods (USDOE EIA, 1998).

The eastern Kentucky coalfields are located in 30 counties consisting of 7.2 million acres. There are 2,295 permanent program permits with 1,361,145 permitted acres in these counties. Of these, 936 permits are surface mining operations with 386,945 acres permitted. These surface mining operations use a variety of mining techniques (i.e. contour, remine, auger, area, mountaintop removal, and any combination of these mine types).

Mountaintop removal and steep slope variance mines are a subset of all surface mines. There are 395 such mines with permanent program permits, amounting to 88,653 permitted acres with permanent program permits. From this total, 219 permits are in an active status, 149 permits have had either a Phase I or a Phase II bond release, and the status of the remaining 27 permits varies. This acreage represents approximately 1.2 percent of the land area in the 30 counties of the eastern Kentucky coal field. These active mountaintop removal/steep slope variance permits account for 6.5 percent of permitted acreage and approximately 17.2 percent of all permanent program permits in the eastern Kentucky coal field.

2. Tennessee

Tennessee is a minor coal producing state, contributing less than one percent of the total U.S. coal production in 1998 (USDOE EIA, 1998). From 1989 to 1994, coal production fell to less than one-half its 1989 level and has decreased slightly since then. The EIA reported production of 1.65 million short tons from 14 surface mines in 1998, accounting for 61 percent of total state coal production. The two largest surface mined coal producing counties in 1998 were Sequatchie, with 537 thousand short tons, and Claiborne, with 435 thousand short tons.

3. Virginia

In 1998, Virginia had the ninth highest coal production of all states at 33.7 million short tons, or 3 percent of the domestic coal production (see Table III.N-1). Virginia coal production has been on a downward trend, having decreased almost 3 percent annually since 1989 (Table III.N-1). The counties of Buchanan and Wise account for over 77 percent of the state's coal production. In 1998, the top producing mine in the State was CONSOL's Buchanan No. 1 underground coal mine, with 4.3 million short tons of coal.

Virginia had 46 operating surface mines in 1998, producing 8.5 million short tons of coal (Table III.N-2) that accounts for 25 percent of the total state production. While overall coal production has decreased, coal produced by surface mining methods increased by 1.1 percent from 1988 to 1997.

Virginia had 127 underground coal mines producing 25.2 million short tons in 1998 (Table III.N-2). This figure accounts for 75 percent of Virginia's coal production. Coal produced from underground mining methods decreased 3.7 percent annually from 1988 to 1997. The continuous mining method was used in the production of 55 percent of the coal produced from underground mines in 1998 (USDOE EIA, 1998).

4. West Virginia

In 1998, West Virginia had the second highest coal production rate of all states at 171.1 million short tons, or over 15 percent of the total nation's output (Table III.N-2). Mineable coal seams occur in 43 of the state's 55 counties. There are 117 identified coal seams in the state; of these, 62 seams are mineable using current technology.

Coal production in southern West Virginia was 126.5 million short tons in 1998, accounting for 74 percent of the state total. While production in northern West Virginia has decreased, production in southern West Virginia has increased at an average annual rate of 2.9 percent from 1989 to 1998, resulting in a net increase in production for the state overall. The four southern West Virginia counties of Boone, Logan, Mingo, and Kanawha account for 47 percent of the total state coal production. West Virginia's highest producing mine is Mingo-Logan Coal's Mountaineer Mine, an underground mine that produced 7.5 million short tons, placing it as the 20th most productive mine in the nation in 1998. The state's top producing surface mine is Samples' Caternary Coal Mine, which produced 4.95 million short tons and ranked 42nd in the nation in 1998 (USDOE EIA, 1999).

Surface mining in southern West Virginia typically occurs at a much larger scale than in neighboring states, with an average production of 684 thousand tons per mine in 1998, compared to 267 thousand tons per mine in eastern Kentucky, 118 thousand tons per mine in Tennessee, and 186 thousand tons per mine in Virginia.

SURFACE MINING ACCOUNTED FOR 40 PERCENT OF SOUTHERN WEST VIRGINIA COAL PRODUCTION IN 1998. THE TOP SURFACE MINING COUNTIES IN 1998 WERE LOGAN, KANAWHA, BOONE, CLAY, AND MINGO.

Coal production by surface mining methods in West Virginia has increased by 6 percent

from 1983 to 1997. The most common surface mining methods in the state are contour, mountaintop removal, and multiple seam operations. Southern West Virginia had 71 operating surface mines in 1998, producing 48.6 million short tons of coal (Table III.N-2). This production accounted for 30 percent of the state's total and 40 percent of all southern West Virginia coal production in 1998. The top surface mining counties in 1998 were Logan, Kanawha, Boone, and Clay and Mingo.

Underground mines in southern West Virginia produced 77.9 million short tons of coal from 209 mines [Table III.N-2]. Coal production from southern West Virginia underground mines accounts for 46 percent of the state's coal production and approximately 60 percent of all southern West Virginia coal production. Underground mining in southern West Virginia, using the continuous mining method, produced 52.0 million short tons in 1998 accounting for nearly two-thirds of all underground mining in that region of the state and 30 percent of the state's total coal output.

O. THE SCOPE OF REMAINING SURFACE-MINABLE COAL IN THE STUDY AREA

1. Demonstrated Coal Reserves

The Energy Information Administration provides an estimate of the demonstrated reserve base of coal in each state, by most likely type of mining method. This EIS deals only with the Appalachian region and bituminous coal seams, where the "demonstrated reserve base" consists of the portion of coal seams that are at least 28 inches thick and no greater than 1,000 feet deep. The demonstrated coal reserve information, as of 1996, is displayed in Table III.O-1. The data in this table includes demonstrated reserves outside of the EIS study area in portions of northern West Virginia and western Kentucky.

Table III.O-1
Coal Reserves and Remaining Production Life

Region	Demonstrated Reserve Base (million short tons)			Remaining Years of Production	
	Underground	Surface	Total	Underground	Surface
Kentucky	1,400	5,600	7,000	19	108
West Virginia	16,800	2,800	19,600	144	49
Tennessee	300	200	500	215	105
Virginia	900	500	1,400	33	49
Four-state Total	19,400	9,100	28,500	na	na
U.S. Total	122,900	151,900	273,900	na	na

Source: U.S. Dept. of Energy, Energy Information Administration, 1998. Coal Industry Annual, 1997.

2. Remaining Extent of Major Surface Minable Coal Seams

a. Introduction

The EIS Steering Committee commissioned several studies to determine the extent of remaining surface mineable coal seams. The seams analyzed account for the majority of current surface mining production as well as the potential future production in eastern Kentucky, central/southern West Virginia, and southwestern Virginia. Defining the location of these seams allows a spatial representation where likely future surface coal mining will result in the types of aquatic, community and terrestrial impacts described and analyzed in other sections of this EIS. One of the principle impacts evaluated by this EIS is excess spoil disposal in valley fills. Portraying the location of remaining surface mineable coal also generally identifies the potential areas where valley fills could occur.

b. Methodology

Information on surface mineable coal zones in Kentucky was provided to OSM under contract with Dr. Jerry Weissenfluh of the Kentucky Geologic Survey (KGS). Nick Fedorko of the West Virginia Geologic and Economic Survey (WVGES) prepared the data for West Virginia coal seams at the direction of the West Virginia Legislature. Dr. Eric C. Westman, Department of Mining and Mineral Engineering, Virginia Polytechnic Institute and State University (VPI), prepared the information for Virginia under contract to OSM. The following reports were provided to OSM , and, as described below, used to prepare the map in this section. The individual reports and GIS coverages are available from OSM or the authors.

b.1. West Virginia

WVGES prepared "Projecting Future Coal Mining in Steep Terrain of Appalachia, " May 2000. The report identifies three surface mineable coal zones in central/southern West Virginia. The coal zones selected by WVGES were based on a review of past and current mining trends, coupled with the general knowledge of the remaining extent of surface mineable seams. WVGES concluded that future surface mining activity will involve the Coalburg coal zone (Coalburg, Stockton and associated riders) and/or the overlying 5 Block coal zone (includes 5 Block, 6 Block and 7 Block). Using standard geologic techniques and a geographic information system (GIS), the contour or outcrop of the Coalburg and 5-Block coals were mapped as a GIS layer for each of the USGS topographic quadrangles in the West Virginia portion of the EIS study area.

Information on areas of existing permitted surface or underground mines and previously mined out areas for each of the coal zones were obtained by WVGES from the West Virginia Division of Environmental Protection and the mining industry. The past and current mining extent was also stored as a GIS cover. OSM developed the areas of remaining coal, using the GIS, by subtracting the mined out and permitted areas from the coal zone extent GIS coverage [see Figure III.O-1].

b.2. Kentucky

KGS submitted "Estimation of Future Mountain-Top Removal Areas in the eastern Kentucky," July 2000. The report covers three surface mineable coal zones in Eastern Kentucky. The outcrop of the Richardson, Broas, and Peach Orchard coal seams were mapped in a GIS coverage. KGS selected this interval because of the historical importance and likely remaining extent of these coals.

Information on areas of existing permitted surface or underground mines and previously mined out areas for each of the coal zones were obtained by KGS from the Kentucky Department of Mines, Department for Surface Mining Reclamation and Enforcement, and the mining industry. The past and current mining extent was also stored as a GIS cover. OSM developed the areas of remaining coal, using the GIS, by subtracting the mined out and permitted areas from the coal zone extent GIS coverage [see Figure III.O-1].

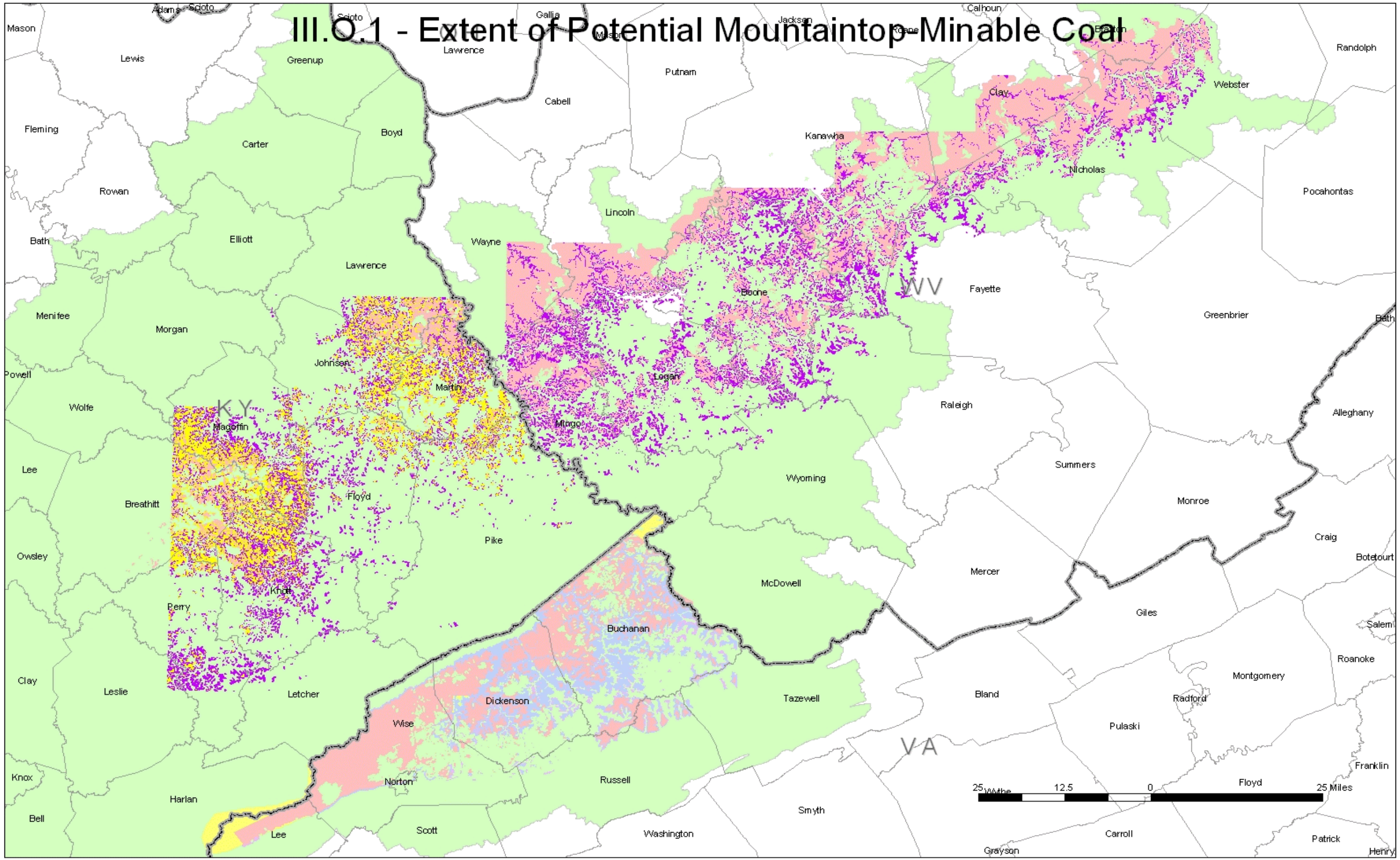
b.3. Virginia

VPI provided the report, "Estimation of South Western Virginia Reserve Base of Surface Mineable Coal," July, 2000. Five coal seams with potential for surface mining were identified based on information obtained from the mining industry and the Virginia Department of Mines, Minerals, and Energy and its Division of Mined Land Reclamation (VADMLR). The seams assessed were the Blair, Dorchester, Norton, Upper Banner, and Lower Banner. The outcrop and extent of these seams were mapped in a GIS coverage.

Information on areas of existing permitted surface or underground mines and previously mined out areas for each of the coal seams were obtained by VPI from the VADMLR and the mining industry. The past and current mining extent was also stored as a GIS cover. OSM developed the areas of remaining coal, using the GIS, by subtracting the mined out and permitted areas from the coal seam extent GIS coverage [see Figure III.O-1].

3. Geologic Extent of Remaining Mountaintop-Minable Coal in the EIS Study Area

It is very important to note that the extent of coal shown on map III.O-1 is <u>not</u> necessarily the extent of future surface mining [see Figure III.O-1]. The maps merely show the extent of coal seams that <u>could</u> be surface mined. The actual mining areas are dependent on the consistency of the coal bed, thickness, stripping ratio, coal quality, size of coal reserve block, and other factors used in site specific mining feasibility analysis. Thus, the areas that will actually be mined will likely be much smaller than the extent of the seam shown.


III.O.1 - Extent of Potential Mountaintop-Minable Coal
Mason
Adams
Scioto
Lewis
Greenup
Lawrence
Gallia
Jackson
Calhoun
Putnam
Cabell
Clay
Webster
Randolph
Fleming
Carter
Boyd
Kanawha
Nicholas
Pocahontas
Rowan
Lincoln
Bath
Elliott
Wayne
Lawrence
Boone
WV
Fayette
Greenbrier
Menifee
Morgan
Johnson
Logan
Powell
Martin
Wolfe
KY
Mingo
Raleigh
Alleghany
Magoffin
Lee
Summers
Wyoming
Breathitt
Floyd
Monroe
Pike
Craig
Owsley
Botetourt
Mercer
McDowell
Knott
Perry
Giles
Buchanan
Salem
Roanoke
Clay
Leslie
Letcher
Montgomery
Bland
Tazewell
Dickenson
Radford
Wise
Pulaski
VA
Franklin
Knox
Norton
Russell
Floyd
Harlan
Wythe
Smyth
Bell
Lee
Scott
Washington
Carroll
Patrick
Grayson
Henry
25 12.5 0 25 Miles

P. DEMOGRAPHIC CONDITIONS

1. Population

From 1980 to 1990, the total population of the study area counties fell by over 140,000, from 2.11 million to 1.97 million–a 6.7 percent decrease. In contrast, the population of each of the states—with the exception of West Virginia—grew over this period. Regarding West Virginia, the study area counties lost population at a substantially greater rate than the state overall—1.4 percent per year compared to 0.7 percent per year for the state. Census estimates for 1998 indicate that the study area's population levels have slightly rebounded to total 2,014,466. Tennessee is the only state in which the study area counties have regained their 1980 population. Total population in the West Virginia study area has declined from 1990-1998, although at a slower rate than the previous decade.
With the exception of West Virginia, the study area population density of each state portion is below that of the state overall. West Virginia's study area counties show similar population densities to the state overall, which are lower than those of the other states encompassing the study area.

The population within the study area may be characterized as predominantly white and non-Hispanic. From 1980 to 1990, the majority of the counties within the study area experienced slight increases in minority levels. Statewide, West Virginia has the lowest proportion of population as minorities. On the other hand, the study area portion of West Virginia shows some of the highest percentage of minorities of all study area counties; five of the study area counties in West Virginia had more than five percent of their population as minority in 1990.

2. Education Levels

For purposes of this EIS, educational attainment was measured as the percentage of the population over age 25 that have not earned a high school diploma. Census data for 1990 indicate that the study area counties lag behind their states in educational attainment as measured by this statistic. On the positive side, educational attainment had increased from 1980 to 1990. However, only some of the study area counties were narrowing the educational gap with their state average; the counties did not show a consistently greater decrease than the state average in the percent of the population without a high school diploma.

3. Income and Poverty Levels

Income Statistics from the 1980 and 1990 Censuses indicate that the study area, as a whole, has a starkly lower income than the individual states. Just four of the sixty-nine study area counties had a per capita income exceeding its state average per capita income in 1990. Moreover, in most study area counties, per capita income grew more slowly from 1980 to 1990 than in the state. Among the states, West Virginia had the lowest per capita income in 1990 and the slowest growth from 1980 to 1990.

Another measure of economic well-being is the estimated percentage of the population with an income below the poverty level. Census statistics for 1980 and 1990 starkly depict a poverty problem throughout most of the study area. The statewide percentage of the population living below

the poverty level increased in West Virginia between 1980 and 1990. The poverty rate in all study area counties in West Virginia grew between 1980 and 1990 and in 1990 all but one of these counties had a higher poverty rate than the statewide rate of 19.7 percent. Over the entire study area, only four of the counties had a lower poverty rate than their respective state and only ten had a poverty rate below twenty percent in 1990. In twenty-four of the study area counties, over one in every three residents was estimated to live below the poverty level.

4. Analysis of Census Statistics for Select Communities

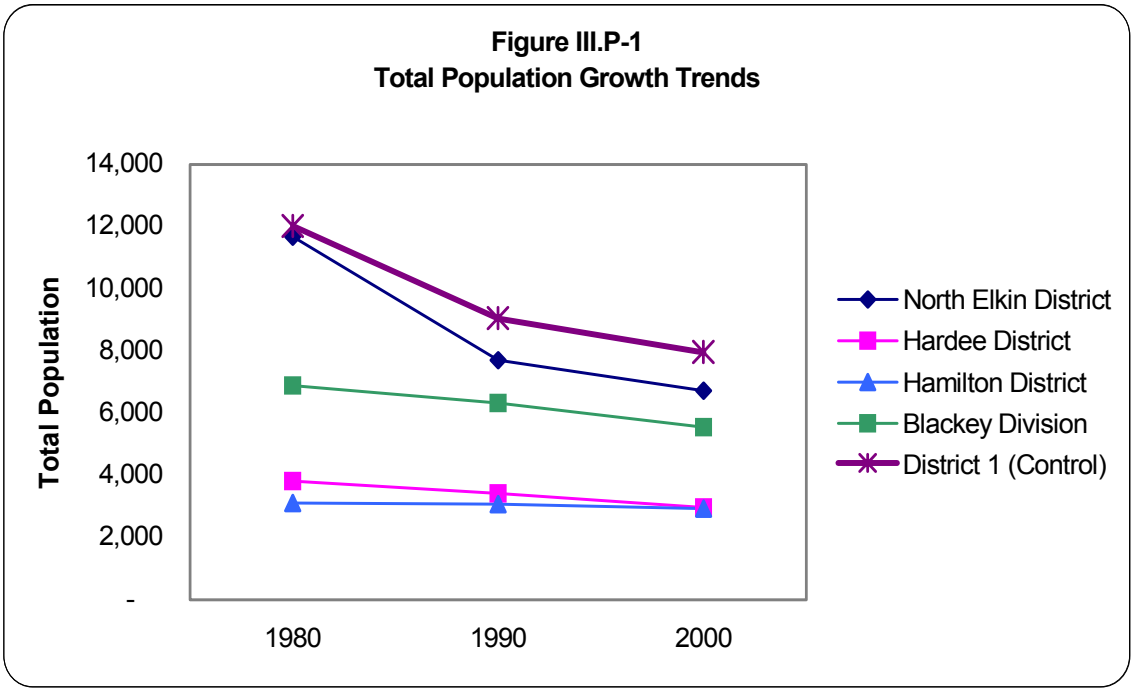
a. Introduction

This section summarizes some of the key socioeconomic data presented in the "Case Studies Report on Demographic Changes Related to Mountaintop Mining". The purpose of this report was to evaluate what, if any, demographic changes can be observed in communities located adjacent to large-scale surface mining operations. The demographic evaluations presented for these communities were based on three decades of census data (i.e., the 1980, 1990, and 2000 decennial censuses) in order to assess the demographic trends that have occurred over time: prior to the introduction of large-scale surface mining operations adjacent to the case study community (i.e., 1980), during large-scale surface mining (i.e., 1990), and after large-scale surface mining (i.e., 2000).
The case study areas include one control area which was selected as similar to others in demographic , geographic conditions and economic resources but within which very little or no significant surface mining had taken place within the time period identified in the study. The case study communities were as follows:

- Hamilton District, community of Werth, Nicholas County, WV
- North Elkin District, community of Kyle, McDowell County, WV
- Hardee District, community of Naugatuck, Mingo County, WV
- Hardee District, community of Scarlet, Mingo County, WV
- Blackey Division, community of Carcassonne, Letcher County, KY
- District One, Wyoming County, WV as the Control Area.

b. Total Population Growth Trends

As illustrated in Figure III.P-1, the study area districts, including the control district, experienced decreases in their total populations over three mountaintop mining periods. The sharpest decrease for the North Elkin and District 1 (control community) districts occurred between the 1980 (prior) and 1990 (during) periods. The population decreases experienced by these census districts are similar to the trends enumerated for their respective counties; that is, the rate of population decline was greater over the 1980 to 1990 period than the 1990 to 2000 period. These trends may, in part, be attributed to an increase in net out-migration patterns, which is most likely associated with the downturn in the local economy that caused local residents to migrate elsewhere to seek employment opportunities.



c. Age Group Composition

Figures III.P-2 and III.P-3 illustrate that the case study communities' populations are aging. Figure III.P-2 illustrates that the proportion of school age group populations steadily decreased over the three census periods for each case study community. Combined with the overall population decline, this proportional decline indicates that the school age population as experienced an absolute increase over the two periods. While the school-age proportion of the populations has declined, the proportion that is of senior age has increased. The increase in the median age level (Figure III.P-4) for the case study communities is further evidence of this aging trend. Therefore, it is highly probable that the local communities will have a population base that is less in need of public school facilities but more dependent on transfer payments, such as social security and public assistance funds; thereby, creating a population having a decreased level of purchasing power and a greater dependence on specialized and public assistance services.

Figure III.P-2
Population Composition Trends - School Age Groups

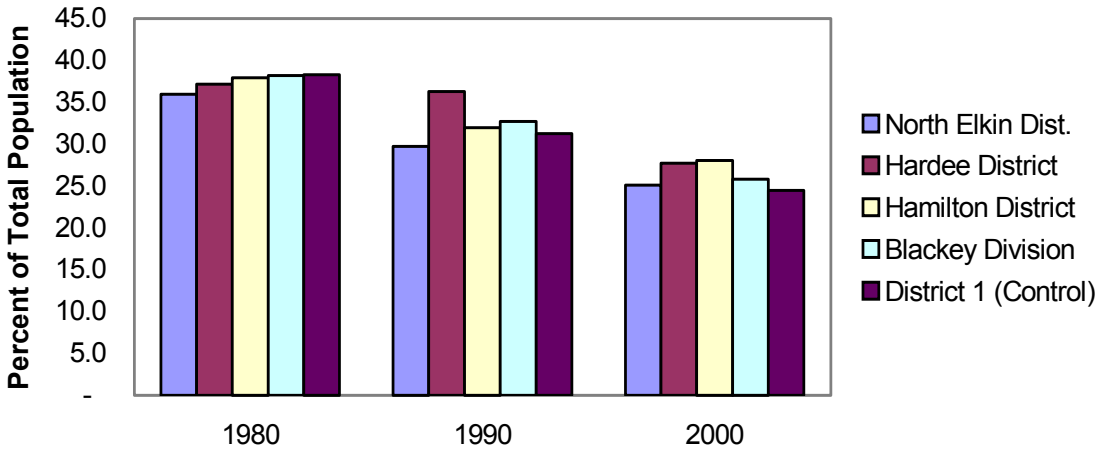
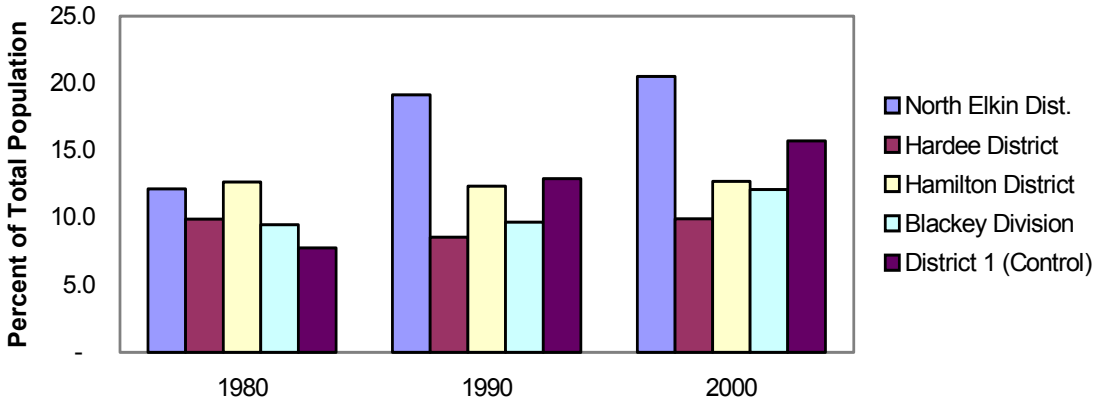
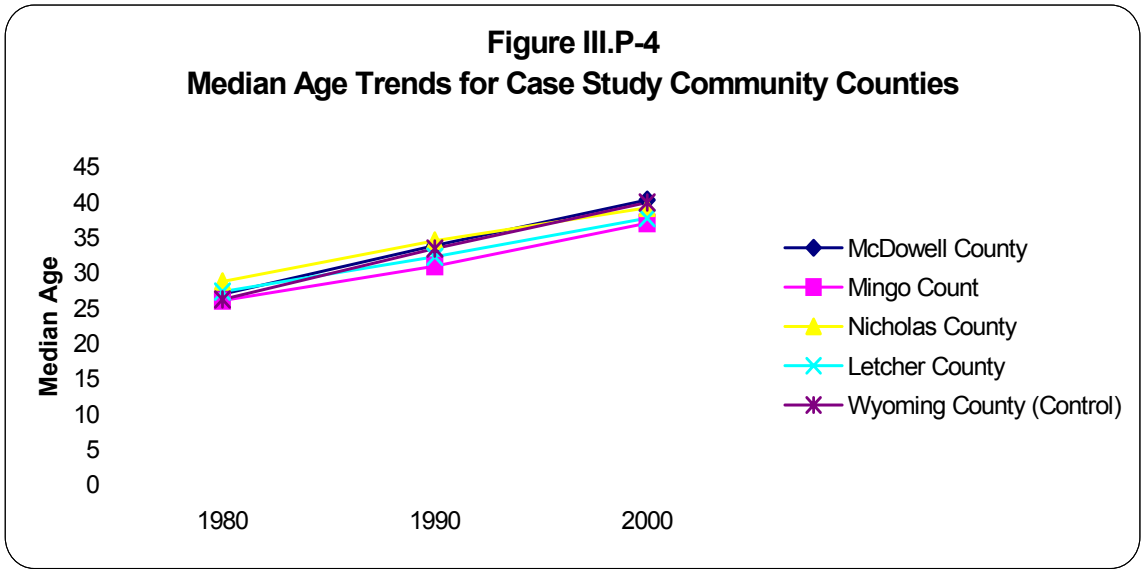


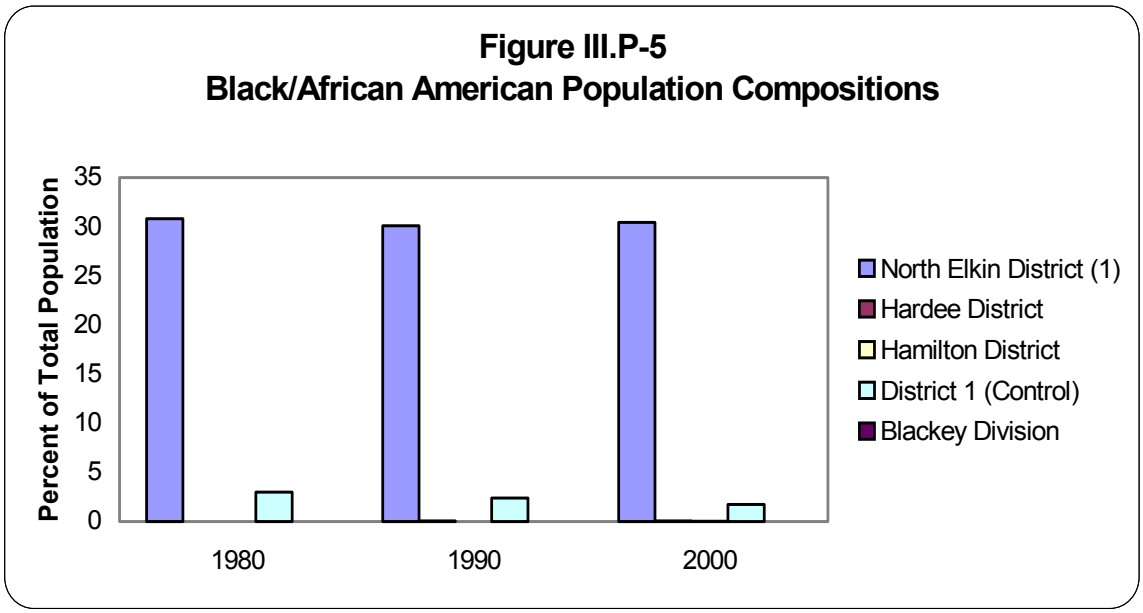
Figure III.P-3
Population Composition Trends - Senior Age Groups





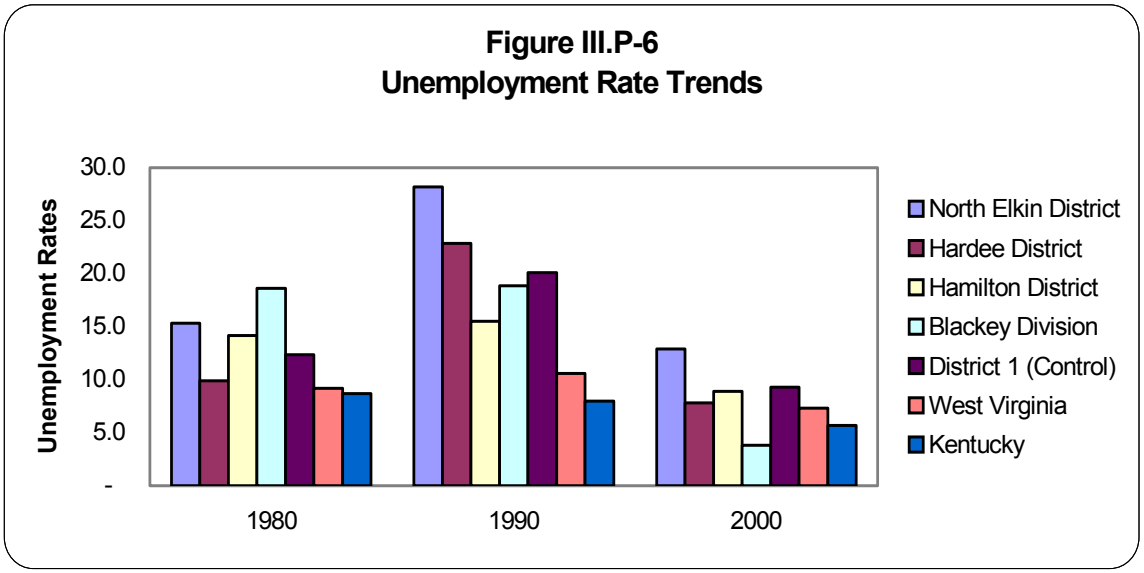
d. Racial Composition

According to the 1980, 1990, and 2000 Censuses, the two largest racial groups comprising the case study communities are whites and Black/African Americans. As illustrated in Figure III.P-5, however, whites comprised a significantly larger share of the case study community populations than blacks/African Americans over the three mountaintop mining periods. The exception to this trend is noted for the North Elkin District (Kyle case study). Black/African American populations are more likely to be impacted by mountaintop mining operations in the North Elkin District compared to the remaining case study communities.



e. Poverty Levels and Unemployment Rates

Figure III.P-6 illustrates unemployment rate comparisons and trends for the case study communities and the states. With one exception (Blackey Division, KY, in 2000), unemployment rates in the communities exceed the state average unemployment rates, with the divergence being the most pronounced in 1990. Unemployment rates have decreased substantially for all studied geographic units over the 1990-2000 time period.



Consistent with the unemployment data, poverty rates in the communities exceed the rates in their respective states for all time periods. Poverty rates increased from 1980 to 1990, but decreased for all but one community for the period 1990-2000. The movements in unemployment and poverty rates for the control community paralleled the movements for the case studies communities; thus, these data offer no evidence that the large-scale surface mining had an effect on these measures of economic well-being.

5. Environmental Justice Populations

a. Regulatory Background

Executive Order (EO) 12898 addresses how executive agencies are to consider environmental justice in their decision-making. The executive order specifies federal agency responsibilities to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Specifically, the executive order requires federal agencies to:

- Conduct their programs, policies, and activities that substantially affect health and the environment so as not to exclude, deny benefits to, or discriminate against persons because of race, color, or national origin.

- Ensure that public documents, notices, and hearings relating to human health or the environment are concise, understandable, and readily accessible to the public.

- Whenever practicable and appropriate, collect, maintain, and analyze information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income. To the same extent, Federal agencies shall use this information to determine whether their programs, policies, and activities have disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. Similarly, Federal agencies are to collect and analyze information on race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial federal environmental administrative or judicial action.

- Collect and analyze information on the consumption patterns of populations who principally rely on fish and wildlife for subsistence.

The Council on Environmental Quality (CEQ) has published guidance regarding federal agency NEPA analyses addressing environmental justice. The CEQ guidance notes that the Executive Order recognizes the importance of research, data collection, and analysis, particularly with respect to multiple and cumulative exposures to environmental hazards for low-income populations, minority populations, and Indian tribes. Thus, data on these exposure issues should be incorporated into NEPA analyses as appropriate. Second, the guidance notes that the EO requires agencies to work to ensure effective public participation and access to information. Third, the guidance references the presidential memorandum accompanying the EO, and states that the memorandum identifies important ways to consider environmental justice under NEPA.

In addition, state regulatory programs, while not specifically required to comply with EO 12898, must still comply with all federal laws that provide the statutory framework for environmental justice. To obtain federal funding, state regulatory authorities must certify to OSM that they will comply with all federal statutes relating to nondiscrimination. For example, states must certify compliance with Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which "prohibits discrimination on the basis of race, color or national origin."

b. Demographic Data Pertinent to Environmental Justice Populations

Environmental Justice statistics on the study areas' populations were collected from the 1980 and 1990 Censuses. These statistics focus on three environmental justice parameters–poverty levels, per capita income levels, and minority population levels. The following narratives present statistical evidence of the degree to which the environmental justice populations exist within the study area. Note that due to programmatic nature of this EIS, it is not feasible to identify specific mining operations and any specific environmental justice populations that may be impacted.

b.1. Poverty Levels

Census statistics for 1980 and 1990 identify an environmental justice population based on the poverty level data presented in Table III.P-1, which starkly depicts a poverty problem throughout most of the study area counties located within the states of Kentucky, Tennessee, Virginia, and West Virginia. The statewide percentage of the population living below the poverty level increased in West Virginia between 1980 and 1990. The poverty rate in all study area counties in West Virginia grew between 1980 and 1990, and in 1990 all but one of these counties had a higher poverty rate than the statewide rate of 19.7 percent. Over the entire study area, only four of the counties had a lower poverty rate than their respective state and only ten had a poverty rate below twenty percent in 1990. In twenty-four of the study area counties, over one in every three residents is estimated to live below the poverty level.

A more compelling analysis of impoverished communities is detailed in the report funded by the Appalachian Regional Commission (ARC) entitled, "Recent Trends in Poverty in the Appalachian Region: The Implications of the U.S. Census Bureau Small Area Income and Poverty Estimates on the ARC Distressed Counties Designation" (2000). This report examines the Census Bureau's *Small Area Income and Poverty Estimates* effects on the ARC *distressed county* designation. According to this report, the greatest number of study area ARC distressed counties in 1980 were located in Kentucky (32 distressed counties or 65.3 percent of the state total), followed by Tennessee (16 distressed counties or 32 percent of the state total). In 1990, Kentucky continued to lead the study area states and increased its number of ARC distressed counties to 37 (75.5 percent of the state total). Tennessee, however, experienced a decrease in the number of distressed counties with only nine (18 percent of the state total) in 1990. Conversely, West Virginia experienced a significant increase in the number of ARC distressed counties; in 1990 the state had 27 distressed counties (49.1 percent of the state total).

Table III. P-1
ARC Distressed Counties by State, 1980 and 1990

State	ARC	1980 Distressed		1990 Distressed		Change	
	Counties	#	%	#	%	#	%
Alabama	35	3	8.6	7	20.0	4	133
Georgia	35	1	2.9	0	0.0	-1	-100
Kentucky	49	32	65.3	37	75.5	5	16
Maryland	3	0	0.0	0	0.0	0	0
Mississippi	21	6	28.6	13	61.9	7	117
New York	14	0	0.0	0	0.0	0	0
North Carolina	29	3	10.3	2	6.9	-1	-33
Ohio	29	2	6.9	7	24.1	5	250
Pennsylvania	52	0	0.0	0	0.0	0	0
South Carolina	6	0	0.0	0	0.0	0	0
Tennessee	50	16	32.0	9	18.0	-7	-44
Virginia	21	1	4.8	3	14.3	2	200
West Virginia	55	7	12.7	27	49.1	20	286
Total	**399**	**71**	**17.8**	**105**	**26.3**	**34**	**48**

Source: Appalachian Regional Commission, 2000

b.2. Per Capita Income

Table III.P-3 reveals that the per capita income levels of the majority of the study area counties are starkly lower than the per capita income levels of their respective states. Just four of the sixty-nine study area counties had a per capita income exceeding their respective state average per capita income in 1990. Moreover, in most study area counties, per capita income grew more slowly from 1980 to 1990 than in the state. Among the states, West Virginia had the lowest per capita income in 1990 and the slowest growth from 1980 to 1990.

b.3. Minority Populations

The population within the study area may be characterized as predominantly white and non-Hispanic. From 1980 to 1990, the majority of the counties within the study area experienced slight increases in minority levels. Statewide, West Virginia has the lowest proportion of population as minorities. On the other hand, the study area portion of West Virginia shows some of the highest percentage of minorities of all study area counties; five of the study area counties in West Virginia have more than five percent of their population as minority. The highest percentage (13.7 percent) of minorities are located in McDowell County, West Virginia.

Q. ECONOMIC CONDITIONS

1. Recent Trends in Unemployment Rates and Employment

Table III.P-2 includes a comparison of the county unemployment rates to those of the state as of 1998. Only five of the 65 study area counties had a lower unemployment rate than the state in 1998. As for the states, each state total shows consistency with the national trend of declining unemployment from 1990 to 1998. West Virginia's unemployment rate was the highest of the four states in 1990 and 1998. West Virginia's unemployment rate in 1990 was higher than in 1980. In contrast, the other study area states had lower unemployment rates in 1990 than in 1980.

The study area counties nearly all show decreases in unemployment rates from 1990 to 1998, and many of the counties show greater improvements than their state average for the period. On the other hand, many study area counties had increases in unemployment rates for the preceding period (1980-1990), or had slower improvements than the state average. Taken together, the changes for the two periods suggest that the study area counties lagged the states in the 1980's in employment improvements and have begun "catching up" in the 1990's.

Employment totals for 1990 and 1997 reveal increases in employment for all study area states in the 1990's, with Tennessee enjoying the fastest employment growth and West Virginia the slowest growth. For the preceding period (1980-1990), West Virginia saw a slight loss of jobs, while the three other states gained jobs. Many study area counties did not share in the employment growth. However, the study area as a whole gained jobs in the 1990's and all but West Virginia's study area gained jobs in the 1980's. In Kentucky, Tennessee, and Virginia, employment in the study area grew more slowly than in the state in the 1990's. In West Virginia, the study area and the state added jobs at the same rate.

ALL STATES AND EACH STATE'S STUDY AREA GAINED JOBS OVERALL BETWEEN 1990 AND 1997. MANY STUDY AREA COUNTIES, HOWEVER, DID NOT SHARE IN THE EMPLOYMENT GROWTH.

2. The Economic Role of Coal Mining

a. Coal Mining Employment

Table III.Q-1 displays mining employment statistics for the years 1980, 1990, and 1997. For the study area, most mining employment is in coal mining. The statistics reveal a decline in mining employment over both periods, with Kentucky and Tennessee experiencing an accelerating decline. Mining employment losses in West Virginia have actually slowed (but not reversed) over the period 1990-1997 compared to the previous decade. The study area portion of West Virginia saw great declines over the period 1980-1990, losing half its mining jobs. The rate of loss has slowed considerably for the period 1990-1997, and is a slower rate of job loss than the state overall. Nevertheless, in 1980, six of the West Virginia study area counties had more than 4,000 mining employees; in 1997 none of the counties had 4,000 or more employees.

DRAMATIC INCREASES IN MINE PRODUCTIVITY SINCE 1980 HAVE LED TO DRAMATIC DECREASES IN COAL MINING EMPLOYMENT, DESPITE INCREASED COAL PRODUCTION.

An examination of mine employment statistics by researchers at Marshall University's Center for Business and Economic Research (CBER 1999) points to the role of increasing productivity in the declines in West Virginia mining employment. The CBER study noted that coal production increased by 40 % over the period 1980-1998 while underground employment declined by 70% and surface mining employment declined by 50%. The study noted that average underground mining productivity in West Virginia increased from 2,100 tons per employee in 1980 to 8,000 tons per employee in 1998.

Table III.Q-1
Coal Mining Employment[1] by County

Place of Work	1980	1990	1997	Avg Annual Percent Change	
				80-90	90-97
Kentucky	58,117	39,566	26,066	-3.8	-4.1
KY Study	*38,774*	*27,199*	*NA*	*-3.5*	*-4.7*
Bell	2,052	1,383	1,007	-3.9	-3.1
Boyd	185	937	859	17.6	-0.9
Breathitt	1,094	895	137	-2.0	-17.1
Carter	164	197	113	1.9	-5.4
Clay	1,727	222	92	-18.5	-8.4
Elliott	131	L	L	NA	NA
Estill	250	178	110	-3.3	-4.7
Floyd	3,595	2,161	1,034	-5.0	-7.1
Greenup	212	48	D	-13.8	NA
Harlan	4,132	3,456	1,384	-1.8	-8.7
Jackson	37	D	D	NA	NA
Johnson	861	469	249	-5.9	-6.1
Knott	1,105	1,124	1,398	0.2	2.2
Knox	657	325	196	-6.8	-4.9
Laurel	583	367	D	-4.5	NA
Lawrence	116	170	D	3.9	NA
Lee	208	241	99	1.5	-8.5
Leslie	502	1,235	1,199	9.4	-0.3
Letcher	2,517	2,153	1,034	-1.6	-7.1
McCreary	309	10	L	-29.0	NA
Magoffin	572	189	D	-10.5	NA
Martin	3,156	1,488	1,012	-7.2	-3.8
Menifee	22	0	0	-100.0	0.0
Morgan	304	35	24	-19.4	-3.7
Owsley	51	16	D	-10.9	NA
Perry	2,808	2,369	1,203	-1.7	-6.6
Pike	9,954	6,427	5,236	-4.3	-2.0
Powell	57	0	36	-100.0	0.0
Pulaski	262	166	131	-4.5	-2.3
Rockcastle	21	16	D	-2.7	NA
Rowan	0	0	12	0.0	0.0
Wayne	92	14	17	-17.2	2.0
Whitley	1,021	889	230	-1.4	-12.6
Wolfe	17	19	D	1.1	NA

Table III.Q-1
Coal Mining Employment by County
(Continued)

Place of Work	1980	1990	1997	Avg Annual % Change	
				80-90	90-97
Tennessee	11,160	8,859	6,654	-2.3	-2.8
TN Study	*5,144*	*2,704*	*1,308*	*-6.2*	*-7.0*
Anderson	511	266	169	-6.3	-4.4
Bledsoe	L	L	0	NA	NA
Campbell	997	433	353	-8.0	-2.0
Claiborne	684	489	117	-3.3	-13.3
Cumberland	462	352	273	-2.7	-2.5
Fentress	132	87	44	-4.1	-6.6
Grundy	64	64	16	0.0	-12.9
Marion	724	120	85	-16.5	-3.4
Morgan	150	104	52	-3.6	-6.7
Overton	95	78	D	-2.0	NA
Roane	221	123	27	-5.7	-14.1
Scott	1,021	334	58	-10.6	-16.1
Sequatchie	83	254	114	11.8	-7.7
Van Buren	0	0	0	0.0	0.0
Virginia	24,740	18,043	13,331	-3.1	-3.0
VA Study	*20,799*	*12,454*	*8,027*	*-5.0*	*-4.3*
Buchanan	7,920	5,002	2,990	-4.5	-5.0
Dickenson	2,598	1,566	627	-4.9	-8.7
Lee	488	345	483	-3.4	3.4
Russell	1,692	871	630	-6.4	-3.2
Scott	58	22	35	-9.2	4.8
Tazewell	2,646	962	754	-9.6	-2.4
Wise	5,397	3,686	2,508	-3.7	-3.8

Table III.Q-1
Coal Mining Employment by County
(Continued)

Place of Work	1980	1990	1997	Avg Annual 80-90	Avg Annual 90-97
WV	67,617	41,793	28,826	-4.7	-3.6
WV Study	*44,358*	*22,248*	*16,643*	*-6.7*	*-2.9*
Boone	5,813	3,826	3,116	-4.1	-2.0
Braxton	190	480	39	9.7	-22.2
Clay	276	233	D	-1.7	NA
Fayette	1,634	857	625	-6.3	-3.1
Kanawha	6,938	2,614	2,296	-9.3	-1.3
Lincoln	159	275	279	5.6	0.1
Logan	5,092	2,750	1,902	-6.0	-3.6
McDowell	7,601	1,665	908	-14.1	-5.9
Mingo	2,724	3,057	2,713	1.2	-1.2
Nicholas	3,337	1,564	593	-7.3	-9.2
Raleigh	5,117	2,423	1,836	-7.2	-2.7
Wayne	249	318	521	2.5	5.1
Webster	237	364	486	4.4	2.9
Wyoming	4,991	1,822	1,329	-9.6	-3.1

Notes:
[1]Includes surface mining, underground mining and coal mining services.
[2]Study area subtotal includes a small number of jobs not disclosed for one of the counties.

D = estimate not shown to avoid disclosure of confidential information
L = estimate less than 10 jobs
Source: U.S. Bureau of Labor Statistics

Table III.Q-2 displays the economic role of mining as measured by the percentage of total employment and earnings directly attributed to coal mining. The table indicates that, at the state level, mining employment and earnings are not significant in Tennessee and Virginia and are slightly over one percent for Kentucky. Although far from its past prominence, mining continues to play a notable role in West Virginia, accounting for over three percent of that state's total employment and over five percent of total earnings. At the county level, mining can be an extraordinarily prominent economic sector. In 1998, mining made up more than ten percent of employment and personal earnings in a number of the study area counties. The higher proportions for earnings compared to employment reflect the high wages in mining. It should be noted that employment earnings are only a portion of all income in a given county. Other income sources include interest, rent, dividends, pensions, and government transfer payments such as social security.

b. Economic Multiplier Impacts of Coal Mining

The economic role of coal mining is understated by these percentages. Coal mine operators purchase goods and services from other firms and coal miners spend much of their wages on goods and s0ervices sold in their regions and states. These purchases have a multiplier effect on the regional and state economies. The Marshall University Center for Business and Economic Research (CBER) study (Marshall University, 2000) used IMPLAN economic multipliers for West Virginia to examine the impacts of coal mining on the state's economy. According to these multipliers, every direct job in coal mining in 1996 supported two other jobs in the state. In terms of the value of output, every dollar's worth of coal production supported an additional 52 cents in sales in the other sectors of the state economy.

Boone County, West Virginia, is an extreme example of how much one county's economy can depend on coal. Coal mining accounted for approximately one-third of all employment in Boone County in 1998. Marshall University's study estimates that the 30.6 million tons of coal produced in Boone County in 1997 supported 5,032 direct and multiplier jobs, $308.3 million in wages at these jobs, and $985 million in output. These direct and multiplier figures attributed to coal, amount to over half of all jobs, two-thirds of all wages, and over four-fifths of the total value of output for the county.

It is worth repeating that Boone County is a very extreme case of a coal dependent economy. Moreover, the statistics quoted above for Boone County apply to all coal mining, while the majority of mining employment in Boone County is in underground mining. No part of the study area is nearly as dependent on mountaintop mining as Boone County is dependent on coal mining in general.

There are a few ways to express the Boone County impacts in terms of unit impacts. At the rates used in the CBER analysis, every million tons of coal produced in Boone County supported 164 jobs, over $10 million in wages, and over $32 million in total output in the county. Expressed as economic multipliers, every direct coal mining job supported another 0.7 of a job elsewhere in the county. Every dollar of coal output supported another 34 cents in output in other sectors of the county economy. As expected, the multiplier effects for the county are lower than those for the state because businesses and individuals make a smaller proportion of their purchases within the county than they do within the state.

Table III.Q-2
Coal Mining Employment and Earnings Percentages

Location	Mining as Percent of Total	
	1998	
	Employment[1]	Earnings[2]
Kentucky	1.2	1.8
Bell	7.5	D
Boyd	D	D
Breathitt	D	D
Carter	D	D
Clay	D	D
Elliot	D	1.5
Estill	D	D
Floyd	9.3	11.9
Greenup	D	0.8
Harlan	12.6	23.0
Jackson	D	0.0
Johnson	2.9	4.0
Knott	26.6	41.8
Knox	1.9	D
Laurel	D	D
Lawrence	D	D
Lee	3.3	0.3
Leslie	D	D
Letcher	13.1	D
McCreary	D	D
Magoffin	6.4	10.1
Martin	26.5	D
Menifee	D	0.0
Morgan	D	0.2
Owsley	D	D
Perry	7.8	D
Pike	17.0	28.0
Powell	D	0.0
Pulaski	D	D
Rockcastle	D	0.0
Rowan	D	1.2
Wayne	D	0.0
Whitley	1.0	1.4
Wolfe	D	0.0

Table III.Q-2
Coal Mining Employment and Earnings Percentages
(Continued)

Location	Mining as Percent of Total	
	1998	
	Employment	Earnings
Tennessee	0.2	0.1
Anderson	0.3	0.3
Bledsoe	0.0	0.0
Campbell	1.8	3.2
Claiborne	D	1.4
Cumberland	D	0.7
Fentress	D	0.2
Grundy	D	0.3
Marion	D	D
Morgan	0.8	D
Overton	D	0.0
Roane	D	0.2
Scott	D	D
Sequatchie	2.8	D
Van Buren	D	0.0
Virginia	0.3	0.3
Buchanan	20.5	33.4
Dickenson	14.9	22.5
Lee	4.3	8.5
Norton	D	D
Russell	4.7	9.9
Scott	D	0.9
Tazewell	3.5	5.0
Wise	D	D
West Virginia	3.3	5.4
Boone	33.0	59.7
Braxton	0.7	0.0
Clay	D	D
Fayette	3.8	D
Kanawha	1.7	2.2
Lincoln	6.2	1.9
Logan	12.1	23.5
McDowell	12.6	D
Mingo	24.2	42.1
Nicholas	5.6	17.0
Raleigh	5.0	10.3
Wayne	16.4	8.6
Webster	15.3	31.0
Wyoming	18.4	34.5

D = Information not Disclosed or Less than $50,000 or 10 jobs.
[1]Employment recorded by county of work, not of residence
[2]Earnings data is reported by place of work and includes wage and salary disbursements, other labor income, and proprietor's income. It does not include dividends, interest, rent or transfer payments, which together account for as much as one-half of income in a county.
Source: U.S. Bureau of Economic Analysis, 1997

The economic impact of mining extends beyond the county where the mine is located. It is common among coal miners to commute long distances to jobs. Thus, while the published employment figures indicate where the wages are earned, they do not reflect where they are spent. In addition, the businesses that provide inputs to the coal industry can be located in other counties or states.

c. Mining-Related Tax Revenues

Coal production provides tax revenues to state and local governments directly through severance taxes and indirectly through royalty payments on public lands, income taxes, property taxes, and federal Reclamation Fund fees. A severance tax is essentially an excise tax imposed on the present and continuing privilege of removing, extracting, severing, or producing a mineral. State and local governments generally levy severance taxes in the form of a percent of the value of the resources removed or sold. Severance tax receipts usually are dependent on energy prices, hydrocarbon production levels, and state and local severance tax rates (EIA 1997). Throughout the study area, coal severance taxes are an important source of revenue for state and local governments and school districts.

COAL PRODUCTION PROVIDES TAX REVENUES TO STATE AND LOCAL GOVERNMENTS DIRECTLY THROUGH SEVERANCE TAXES AND INDIRECTLY THROUGH ROYALTY PAYMENTS ON PUBLIC LANDS, INCOME TAXES, PROPERTY TAXES AND FEDERAL RECLAMATION FUND FEES.

Coal production supports abandoned mine land reclamation projects and the United Mine Workers Combined Benefit Fund through the Special Reclamation Fund fee levied under SMCRA Section 402. Surface mined coal is levied a fee at a rate of 35 cents per ton; underground mined coal is levied a fee at a rate of 15 cents per ton. Half of these revenues are supposed to be returned to the state in which the coal was produced, to be used in funding reclamation or acid mine drainage abatement projects at abandoned mines. However, an ongoing controversy over federal congressional management of the AML Fund surrounds the continuing accrual of "excess" funds into the account as collections substantially exceed distributions from the fund. Although the management concerns exist, a significant amount of money does flow to the study area states from the fund. In FY 1999, more than 47 million dollars went to AML programs in the study area states. Kentucky received 22.7 million dollars, West Virginia received 20.2 million dollars, Virginia received 4.4 million dollars, and Tennessee received 0.1 million dollars (OSM Annual Report 1999).

c.1. Kentucky

Kentucky's severance tax rate for coal is 4.5 percent of the gross value of all coal severed and/or processed, with a 50 cent per ton minimum. In 1998, the effective severance tax rate as a percent of the price of coal averaged 4.3 percent. The state collected 186 million dollars in coal severance taxes in that year, accounting for three percent of the general revenue fund and approximately 1.3 percent of total state revenues (Commonwealth of Kentucky, Office of the Controller 1999).

The continued decline in coal prices produced a reduction in receipts received from energy severance taxes. For example, Kentucky collected 203.3 million dollars in fiscal year 1992-93 and 186.1 million dollars in fiscal year 1997-98. Although still an important source of revenue-particularly for local governments–the reliance on coal severance tax receipts has generally declined.

The state established the Local Government Economic Development Fund to provide coal severance tax revenue grants to coal producing counties to assist in the diversification of their local economies. Each coal producing county is allotted a portion of the fund money for use exclusively in that county, and a portion is set aside for multi-county or regional projects. The fund has grown to 82 million dollars in 1997. The percentage of coal severance taxes returned to counties from the fund has increased from 12 percent in 1992 to 31 percent in 1998.

c.2. Virginia

Virginia's local coal and gas road improvement tax and natural gas severance tax are used to provide funds for economic development loans through the Virginia Coalfield Economic Development Authority. According to the Authority's 1998 annual Report, six projects received loans totalling over 3.1 million dollars and six projects received grants totalling 270,000 dollars.

c.3. West Virginia

The major categories of revenue for the West Virginia state government include the General Revenue Fund, the State Road Fund, lottery funds, federal funds and special revenue funds. The General Revenue Fund includes funds from income tax, sales tax, business and occupation taxes and the Natural Resource Severance Tax. The severance tax is levied as a 5 percent privilege tax on the gross receipts on the sale of the product severed. Ninety percent of severance tax revenues come from coal production. Severance tax receipts are allocated to the General Revenue Fund (77 percent), the State Infrastructure Fund (13 percent), local governments (8 percent), and the State Division of Forestry (2 percent). (West Virginia State Budget Office 2000). Based on estimates by the State Budget Office, coal severance taxes contribute roughly five percent of the General Revenue Fund. Recent and projected severance tax receipts are shown in Table III.Q-3.

Approximately 80 percent of severance tax revenues are distributed to local governments. One-fourth of this amount is distributed among municipalities in proportion to population and the remaining three-fourths is reserved for distribution among the coal producing counties in proportion to value of coal production.

Coal mining also contributes to public finance through other taxes, including the various property taxes and income taxes. Property taxes related to active coal mines contributed approximately 43 million dollars statewide in the past fiscal year. Taxes collected on the assessed value of coal reserves contributed another 14 million dollars. Combined, these property taxes accounted for approximately 34 percent of all property taxes collected statewide. Property taxes are a major income source for county governments and school districts in West Virginia. Approximately 68 percent of property tax revenues are allocated to schools and these revenues account for roughly 30 percent of the typical school district budget (Muchow 2000).

Table III.Q-3
West Virginia Severance Tax Receipts, 1997-2003

Fiscal Year	Severance Tax Receipts ($ million)
1997	176.9
1998	175.2
1999	148.4
2000*	161.5
2001*	145
2002*	139.5
2003*	133

* = Projected
Source: West Virginia State Budget Office 2000.

Boone County is an example of a county with a considerable role for coal in its finances. Approximately 4 million dollars in property tax revenue is directly linked to coal production (approximately 10% of its school district budget) and the county received 2.2 million dollars in severance tax distributions in the previous fiscal year (Muchow 2000).

d. The Economic Role of Surface Coal Mining

As labor productivity improved between 1970 and 1997, the number of miners fell by 2.1 percent per year on a national average level and 4.9 percent in the study area. The numbers of miners in surface mining and all coal mining in the study area are displayed in Table III.Q-4 below.

The table illustrates a substantial decrease in the number of miners between 1989 and 1998. In all states and regions shown, the rate of decline in the number of surface miners is less than that of all miners, indicating that the numbers of underground miners have fallen even more notably than the numbers of surface miners. With productivity improvements expected to continue through 2020, the EIA projects a further decline of 1.3 percent a year in the number of miners in the U.S. (EIA, 2000).

Table III.Q-4
Average Number of Coal Miners

Region	1998		1989		Avg. Annual % Change (1989-1998)		Surface Miners as % of Total	
	All Mines	Surface Mines	All Mines	Surface Mines	All Mines	Surface Mines	1998	1989
Eastern Kentucky	14,617	5,164	24,620	8,034	-5.6	-4.8	35%	33%
West Virginia Total	17,167	4,019	29,482	6,434	-5.8	–5.1	23%	22%
So. West Virginia	13,028	3,507	19,202	4,810	-4.2	-3.4	27%	25%
Tennessee	517	244	1,857	386	-13.2	-5.0	47%	21%
Virginia	5,734	1,108	10,371	1,482	-6.4	-3.2	19%	14%
Study Area	38,035	10,535	66,330	16,336	-4.7	-4.0	28%	25%

Source: U.S. Department of Energy, Energy Information Administration. 2000. *Coal Industry Annual 1998.*

The table displays that surface mining employs a minority of the coal miners in the study area. Slightly over one in three eastern Kentucky coal miners in 1998 was a surface miner, while just over one in four miners in southern West Virginia was a surface miner. In 1988, approximately one in five miners in southern West Virginia was a surface miner. The more rapid declines in underground mining employment have increased the share of surface miners in total mining employment for all states and regions shown.

SLIGHTLY OVER ONE IN THREE EASTERN KENTUCKY COAL MINERS IN 1998 WAS A SURFACE MINER, WHILE JUST OVER ONE IN FOUR MINERS IN SOUTHERN WEST VIRGINIA WAS A SURFACE MINER.

Data from the West Virginia Bureau of Employment Programs were used to estimate the proportion of total mining employment in the West Virginia study area counties which corresponds to surface mining. Use of the category "surface mining" is essentially equivalent to "mountaintop mining" for the West Virginia study area counties. Surface mining employment data were not identified for the counties in the other study area states and were not available for all study area counties in West Virginia.

According to the West Virginia Bureau of Employment Programs, approximately 23 percent of bituminous coal mining employment in Boone County was engaged in surface mining in 1998 and 37.5 percent of all employment in the County was in coal mining, including coal mining services. Combining these percentages yields the statistic that 8.6 percent of Boone County employment in 1998 was directly related surface mining. Surface mining proportions for the other West Virginia counties with available data are shown in Table III.Q-5

The data in Table III.Q-5 indicate that, as measured by percent of workers, surface mining is particularly important in the economies of Boone, Logan, and Mingo counties. Although not shown directly in the table, underground mining is a major source of employment in Boone, McDowell, Mingo, and Wyoming counties.

Table III.Q-5
West Virginia Surface Mining Employment, 1998

	All Coal Mining	Surface Mining Employment	
County	% of All Employment	Percent of Bituminous Mining Employment	Percent of Total County Employment
Boone	37.5	22.8	8.6
Fayette	4.6	61.2	2.8
Kanawha	1.1	53.2	0.6
Logan	13.2	58.6	7.6
McDowell	15.7	12.3	1.9
Mingo	29.1	37.7	11.0
Nicholas	7.1	30.0	2.1
Raleigh	5.9	7.8	0.5
Wyoming	21.9	1.4	0.3

Source: West Virginia Bureau of Employment Programs, 1999

3. Economic Projections

a. Central Appalachia Baseline Coal Economy Projections from EIA and University of Kentucky

The year 2001 Energy Information Administration (EIA) baseline scenario forecast for central Appalachia (the coal production region that encompasses the study area exclusive of Tennessee) projects a modest (4.8 percent) decline in coal production, combined with a considerable (14.2 percent) fall in prices over the period 1997 to 2010. The two decreases combine for an 18.3 percent decrease in coal sales and a projected loss of 7,700 coal mining jobs (Univ. of Kentucky Center for Business and Economic Research 2000, p.115).

This direct employment loss is estimated as corresponding to a 2.4 percent decline in employment in the central Appalachian region. The associated earnings loss is estimated as accounting for a 3.4 percent decline in earnings in the region (Univ. of Kentucky Center for Business and Economic Research 2000, p.117). The University of Kentucky study applied economic multipliers to the direct employment changes to estimate a 6.5 percent decrease in all jobs (directly and indirectly related to coal mining) and a 6.1 percent decrease in total earnings (Univ. of Kentucky Center for Business and Economic Research 2000, p.120).

b. Marshall University Study for the West Virginia Senate Finance Committee

A study commissioned by the West Virginia Senate Finance Committee and conducted by Marshall University's Center for Business and Economic Research found a similar result for a nine-county study area in southern West Virginia. The Marshall University study examined economic impacts of three different coal production scenarios for a one-year period (2000). Their baseline forecast projects a one percent decline (1,646) in total private sector employment resulting from an approximately seven percent decline in coal production. Their county-by-county analysis projected greatly varying results among counties, with some projected to actually gain employment, and others to lose as much as 7.8 percent of total employment as a result of a decrease in mining jobs and associated multiplier jobs (Marshall University CBER 2000).

The Marshall University study and the University of Kentucky study reported above focus on the coal-mining economic impacts. The losses projected in these studies are the jobs and earnings that would be subtracted from these economies due to coal mining losses. These studies do not project actual total employment and earnings changes, net of other economic changes. Indeed, there are other economic forces at work that are projected to bring new economic base jobs and associated multiplier employment. The direct and multiplier losses reported in these studies indicate the extent to which the mining losses place a drag on the subject economies. That is, they measure (very roughly) how many more jobs the economy would have gained, had the mining jobs not been lost. The West Virginia statewide economic outlook described below illustrates a projection of a net overall positive change in the statewide economy, despite considerable losses in coal mining.

c. Statewide Overall Economic Forecasts

A 10-year forecast in the West Virginia Economic Outlook (WVU BBER 2000) calls for a continuation of the recent trend of slower growth in the state. The forecast calls for West Virginians to be better off (in terms of real per capita personal income) in 2010 than they are now. The forecast also suggests that state growth will fall short of that expected for the nation. This slowed relative growth implies a widening per capita personal income gap with the nation in coming years.

The long-term outlook for job growth calls for modest annual gains through 2010, with state job growth falling well short of national growth. All net job gains are expected to come in the service-producing sectors, with goods-producing jobs continuing their downward slide. Mining jobs (especially coal mining) are expected to drop at a swift pace. (WVU BBER 2000)

Job growth in construction is expected to be slower during the next 10 years than it was during the 1990s. The outlook also calls for manufacturing jobs to decline, although at a slower pace than during the previous 10-year period. This slowdown in manufacturing job losses is primarily due to job gains in durable manufacturing (especially lumber and wood products and transportation equipment). Nondurable manufacturing jobs decline during the forecast, as job losses in chemical products and apparel overwhelm gains in printing and publishing and food products. (WVU BBER 2000)

A large factor in the overall job growth slowdown during the forecast is the deceleration in job growth in services. This sector is expected to remain the fastest growing industry in the state (in terms of generating jobs), but that growth is likely to be slower than it has been. The slowdown is

expected to permeate all services sectors, including business services, health care services, social services, and membership organizations. The forecast calls for business services (which has produced very strong job gains this decade) to continue to lead the pack in services job growth during the next 10 years. Further, travel-related services are likely to continue to grow in the state. (WVU BBER 2000)

The forecast calls for the state's population to register moderate losses during the forecast, as slow job and income growth are insufficient to stem outmigration. Finally, the forecast calls for the unemployment rate to stabilize in the 5.5-6.0 percent range. (WVU BBER 2000)

R. LAND USE AND POTENTIAL DEVELOPMENT

1. Historical and Current Land Uses

The two most important features of the study area in determining land uses are the natural landscape and the ownership of rights to the potentially mineable coal beneath the land surface. The steep slopes and the narrow, flood prone river valleys severely constrain the available supply of developable land. Most of the land is in forest cover and human occupation is generally concentrated in stream valleys.

a. Current Land Uses, Study Area Overall

The overwhelming land use in the study area is forest which covers approximately 11 million acres or 92 percent of the approximate 12 million acre study area. Deciduous forests cover over 9 million acres or 79 percent of the study area. Mixed deciduous and evergreen forest comprise 9 percent of the study area. Developed areas (residential, commercial and industrial) account for about 1 percent of the study area.

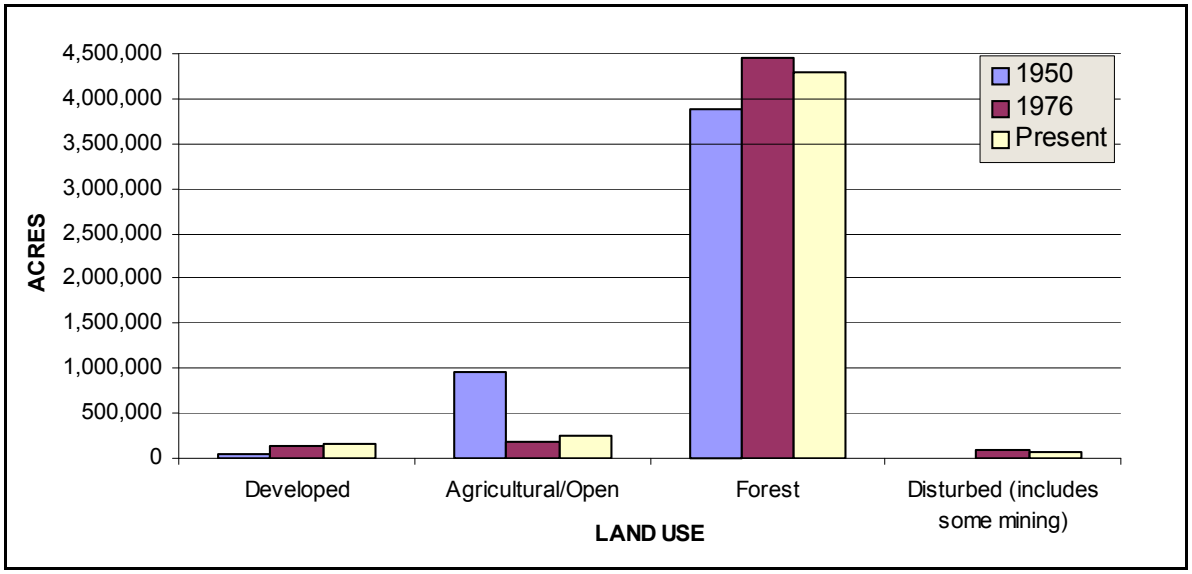
b. Current Land Uses, West Virginia Study Area

The *West Virginia University Land Use Assessment* (2002) was conducted to examine land use issues associated with mountaintop mining in the 14 county study region of southern West Virginia. The results were derived from a classification of recent Landsat satellite data. The satellite data were classified and converted to a GIS (geographic information system) coverage for analysis and display. Results confirm the forested/lightly developed character of the West Virginia mountaintop mining region. Almost 88%, or slightly over four million acres, was classified as mature forest land with the diverse mesophytic forest type being most prevalent at almost three million acres of area. All developed land uses (intensive urban, moderately intensive urban, light urban, populated areas, major roads, and infrastructure such as power lines) accounted for 155,000 acres or roughly three percent of the land area. Agricultural land uses were found on approximately a quarter of a million acres or five percent of the land area. Other general land use/land cover categories include: shrub land and woodland areas with slightly over 63,000 acres; water/wetlands with 56,000 acres or one percent of the land area; and barren land – mining being 74,000 acres or 1.5% of the study area.

c. Patterns of Land Use Changes, West Virginia Study Area

Figure III.R-1 presents general land use/land cover changes for the 14 county West Virginia study area examining three different time periods – 1950, 1976, and 2001 ("current conditions"). Data for 1950 were obtained from detailed paper maps that were compiled during a four-year land cover-mapping project that was completed by the U.S. Forest Service for West Virginia. The 1976 data source is the USGS GIRAS land use data that were digitized by USGS from 1976 vintage 1:48,000 scale aerial photography. The current data are from the results of the WVU – NRAC satellite data classification effort.

Figure III.R-1
Land Use Characteristics for the West Virginia Study Area



Source: WVU 2002, *West Virginia Land Use Assessment*

An analysis of the data from these three periods reveals the following general patterns of land use change in the region:

- The acreage of developed area increased from 42,533 acres in 1950 to 154,966 acres currently. This acreage probably does not include much of the dispersed development that dominates the region.
- Agricultural acreage *decreased* from almost a million acres in 1950 to 188,000 acres in 1976 and then *increased* to 246,000 acres by 2001. Much of the acreage increase in this second period is due to coal mining and reclamation that converted areas from existing forest land to grassland/pasture.
- Forest areas increased from under four million acres in 1950 to almost 4.5 million acres in 1976 and then fell to under 4.3 million acres by 2001. The current loss of forest land is due to patterns in mine reclamation converted land from forest to open–grassland/pasture and to new urban development in the region.
- Disturbed areas increased from just over 3,000 acres in 1950 to a high of 85,000 acres in 1976 and over 73,000 acres currently. This acreage are areas that were not vegetated in those time periods. Lands that are not vegetated and otherwise fit in no other categories are classified as "disturbed". Revegetated mined lands would not fall under this category.

A separate estimation of the extent of mining was developed by WVU for the land use study because other sources generally significantly underestimate mined areas by placing reclaimed areas into other land use/land cover categories such as grassland/pasture and forest. A compilation of various data sources indicate that over 244,000 acres or approximately 5% of the West Virginia mountaintop mining study area contains evidence as having been disturbed by past or current mining. Mining related land uses are the second most prevalent land use/land cover in the region – after forest land.

This total includes a number of different mine types – unreclaimed abandoned mines, unreclaimed mines with forfeited bonds, reclaimed mines (where the resulting post-reclamation land use allowed for identification and delineation), and active mines. Again it is probable that significant mined areas were undetected by the various data sources, as well as subsequent checking and verification. Also, this estimate does not include areas that have been fully reclaimed or converted to a post-mining land use or off-site impact areas such as clogged stream channels.

2. The Role of Land and Mineral Ownership

In many coal producing areas, the surface and subsurface ownership rights are held by different parties. This separation became a source of conflict with the growth of surface mining because the removal of the mineral entails destruction of surface uses and structures. SMCRA requires the permission of the surface owner or explicit rights by deed or contract as a prerequisite to processing a permit application.

Because the economics of coal production favor large scale operations, it is common for coal mining interests to control potentially mineable land in large blocks. These owners may be land companies that own the land for the purpose of collecting royalty payments from coal mining companies, coal mining companies themselves, diversified fuel conglomerates, electric utilities, or others. When the potential value of the underlying coal is greater than the return from surface development of the land, mineral owners have an incentive to prevent land development (Miller 1974).

Concentration of mineral ownership and associated limitations to the availability of developable land occur in the study area. For example, a study in West Virginia in 1974 found that 23 owners owned 91 percent of surface acreage in Boone County, 17 owners controlled 59 percent of Fayette County, and six major landowners owned 23 percent of the acreage in Kanawha County (Miller, 1974). The Mountain Association for Community Economic Development (MACED) examined private mineral ownership maps and deeds for Letcher County, Kentucky in 1998. MACED found that eighteen owners (sixteen corporations and two private individuals) owned mineral rights in at least 65 percent of the county's land mass of 217,000 acres (MACED 1999). The 65 percent is a minimum because information on parts of the county was not available to MACED. Few of the owners were located regionally. Several of the top owners were based outside of the Appalachian region.

3. Land Use and Economic Development Planning

The region's economic dependence on its exhaustible coal resources, its need to diversify, and its need to further develop the human resources and infrastructure to support economic development are widely recognized. Most leaders are also keenly aware that its coal resources are its best source of leverage for investments needed to build an economy that can continue to flourish after the inevitable decline of coal mining. The collection and distribution of coal related taxes was described in section III.Q. This subsection describes the institutional framework for economic development planning and promotion.

There are a number of agencies at the regional level which address planning and development issues within the study area. Regional agencies include those created at the federal level, such as the Appalachian Regional Commission (ARC) and those created at the state level such as Kentucky's Office of Coal County Development. The following is a brief overview of these agencies.

a. Appalachian Regional Commission (ARC)

ARC was established by Congress in 1965 to support economic and social development in the Appalachian Region. ARC undertakes projects that address five goals: 1) developing a knowledgeable and skilled population; 2) strengthening the region's physical infrastructure; 3) building local and regional capacity; 4) creating a dynamic economic base; and 5) fostering healthy people.

To meet these goals, ARC helps fund such projects as education and workforce training programs, highway construction, water and sewer system construction, leadership development programs, small business startups and expansions, and the development of health care resources. ARC's area development funding functions include the Distressed Counties Program, which provides special funding for the region's poorest counties. Forty-seven of the study area's 69 counties are designated as "distressed counties" for fiscal year 1999.

ARC works with the states to support a network of multi-county planning and development organizations, or local development districts (LDDs). The LDDs most important role is to identify priority needs of their local communities.

b. Kentucky

In 1997, the state of Kentucky created the Office of Coal County Development to assist coal producing counties in diversifying their economies beyond coal. The Office of Coal County Development is charged with overseeing the Local Government Economic Development Fund (LGEDF). This fund, described briefly in section III.Q, distributes coal severance tax revenues. The principle economic development planning functions in eastern Kentucky are carried out by the Area Development Districts (ADD).

c. Virginia

The Virginia Area Development Act authorized the establishment of twenty-one planning district commissions in the state. Of the twenty-one, two serve the seven counties and one city within the Virginia coalfield area. Examples of planning district commisstion projects range from recreation programs to zoning and comprehensive planning assistance.

d. West Virginia

The land use planning function in West Virginia, when it is carried out at all, has usually been carried out by ad hoc boards and commissions, which are not integrated into local policy development or decision making. Planning has not been internalized as a central policy or program concern of local government. A number of counties have no planning commission and, of those that do, some have no staff and no effective power. Only some of the counties have adopted comprehensive plans, zoning ordinances, or subdivision/land development ordinances. There is a consensus for local planning in the three more heavily developed counties in the region – Fayette, Kanawha, and Raleigh Counties, but not in a majority of the region. Within the counties, there are several incorporated municipalities that have adopted various levels of planning functions and controls.

At the state level, the West Virginia Development Office has a number of functions relating to economic development in the study area. The Community Development Division administers a variety of state and federal programs to help develop human resources and install public utilities, access roads, buildings, streets, sidewalks and other public improvements.

Enrolled Senate Bill 681 of 1999 established the Office of Coalfield Community Development within the West Virginia Development Office. Among other duties, the office is responsible for overseeing the preparation of community impact statements by coal operators and for coordinating the preparation of coal field community development statements.

Local communities (even those with active planning) do not really have much direct control over post-mining land use planning and reclamation. However, post-mining land use compatibility with community zoning or subdivision ordinances may be evaluated by the SMCRA regulatory authorities. Local planning and ordinances may be considered during WVDEP's review of the mining permit and proposed post-mining land use plans (WVU Land Use Assessment 2001).

4. Land Use Needs and Development Potentials

a. Intensive Human Use

Two of the factors most often cited as hindering economic development in Central Appalachia are the rugged terrain and the poor access. The Appalachian Regional Commission has been attacking the access limitations since its inception in the 1960s, with an aggressive highway funding program. Access to much of the study area has improved over the years, although not all counties are readily accessible. The steep slopes and narrow, flood prone valleys have limited the availability of land parcels suitable for large scale development. The provision of large parcels of flat to gently sloped terrain is therefore sometimes cited as a positive potential side effect of mountaintop removal and steep slope AOC variance reclamation. The usefulness of such flattened land is dependent on the presence of other factors supportive of development, such as infrastructure and excess market demand for developable land.

THE STEEP SLOPES AND NARROW, FLOOD PRONE VALLEYS HAVE LIMITED THE AVAILABILITY OF LAND PARCELS SUITABLE FOR LARGE SCALE DEVELOPMENT.

An analysis of West Virginia region-wide land development potentials, limitations, and demands was completed as part of the WVU Land Use Assessment study using the Clarke Urban Growth Model (WVU Land Use Assessment 2001). The results indicate that over 1.3 million acres or 28% of the land in the region were placed into the highest category that was judged to be land with some opportunity for development – though some development restrictions might be present (e.g. unstable soils). An additional 20% of the region was placed into a moderate development potentials category indicating development potential with potentially significant development restrictions (e.g. flood potentials). The remaining three classes: limited, severely limited, and highly restricted, represent areas where development restrictions generally far outweigh the development opportunities that are present. Almost 50% of the region has limited development potentials due to the presence of what are often multiple severe development restrictions.

These results indicate that though much of the undeveloped land in the region has limited development potentials, there is a significant supply of undeveloped but developable land. However, these lands are not evenly distibuted among the counties, and moderate development restrictions may need to be addressed in developing most of these areas (e.g. flood protection or special methods for steep slope conditions).

b. Recreation

Public land needs and demands are very heavily tied to recreation development in the region. There are certainly localized demands for public lands for uses such as schools, community parks, and other public facility developments (WV State Comprehensive Outdoor Recreation Plan 1997). However, the acreage requirements for most of this development are minimal, and will be linked to existing community locations in most cases. A compilation of the major demands for public lands in the region identified by various federal and state agencies shows significant differences between counties in the region in the need/demand for hunting and fishing, water recreation, and special needs recreation areas – facilities that generally require significant areas. Counties that have a high demand/need for one or more of these activity areas are Kanawha, Lincoln, Logan, Raleigh and Wayne Counties (WVDNR Capital Improvements Plan 1998) (WVU Land Use Assessment 2001).

c. Commercial Forestry

The wood products industry in West Virginia has been a growing economic force in the state. However, a Division of Forestry inventory indicates that industry growth could become constrained by timber supply limitations. An increase in the lands in commercial forestry would help to continue to feed the growth of the study area's wood products industry.

d. Future Land Use Needs

Future land use development needs are difficult to estimate for the West Virginia study region because it is anticipated that the majority of the region will continue to lose population or current population levels will remain static. Population projections for current conditions to 2010, estimate that only Raleigh County will have a significant demand for new land use development based on anticipated population growth. This demand is estimated to range between 1,483 and 3,954 acres of required new development for the ten-year time period. Kanawha County is also expected to require new land for urban expansion. However, much of this area is actually due to shifting development patterns rather than new growth. Projections indicate between sixteen and thirty new square kilometers of new urban land uses will be potentially developed in Kanawha County between 2000 and 2010. The other counties in the study area will require insignificant acreage for the new development that is anticipated during the ten year 2000 to 2010 time period (WVU Land Use Assessment 2001).

S. HISTORIC AND ARCHAEOLOGICAL RESOURCES

Historic and archaeological resources are sometimes broadly categorized as "cultural resources." Cultural resources consist of prehistoric and historic districts, sites, structures, artifacts, and other physical evidence of human activities considered important to a culture, subculture, or community for scientific, traditional, religious, or other reasons. Prehistoric and historic archaeological resources are locations where human activity measurably altered the earth or left deposits of physical remains. Typical environments in which archaeological resources can be found include rock shelters, terraces, floodplains, Native American burial mounds, and ridgetops. Architectural resources, which may include dams, bridges, and other structures having historic or aesthetic importance, generally must be older than 50 years to be considered for protection under existing federal cultural resource laws.

Cultural resources that may be present within mine sites include cemeteries, historical sites and structures, archeological sites, public parks, and other features of cultural significance to surrounding communities. Historical cemetery sites may exist in coal mining areas because they were often located on mountaintops and ridge crests. SMCRA prohibits mining within 100 feet of a cemetery, although cemeteries may be relocated if authorized by applicable state laws or regulations. Mining may not be conducted in public parks or places listed in the National Register of Historic Places without joint approval of federal, state, and local agencies with jurisdiction over these features. Consultation under Section 106 of the National Historic Preservation Act compels agencies to consider the impact of mining projects on historic properties and the various alternatives to minimizing adverse effects. Permit applicants may be required to conduct archeological surveys of proposed mine sites if the reviewing agencies believe that archeological sites may be present. Mining is not allowed in the National Park System, the National Wildlife Refuge System, the National System of Trails, the National Wilderness Preservation System, the Wild and Scenic Rivers System, or National Recreation Areas unless valid existing rights can be demonstrated under the guidelines established in 30 CFR 761.16.

Areas of community concern but not otherwise designated for regulatory protection may also become a consideration during the permitting process. An example of this would be the recent controversy over proposed plans to mine on Blair Mountain in West Virginia, site of a bloody conflict between coal operators and miners attempting to unionize in 1921.

Lists of known recorded cultural resource sites for the study area are maintained by the Kentucky, Tennessee, and West Virginia State Historic Preservation Offices, and the Virginia Department of Historic Resources. In addition, the National Park Service maintains an online version of the National Register Information System (NRIS) [http://www.nr.nps.gov/nrishome.htm].

The first evidence of human habitation in the Appalachians relates to the Paleo-Indians period, perhaps as far back as 13,000 B.C. Such sites have been investigated in Pennsylvania and Virginia. Gardner has investigated the earliest known structure in the New World at the Thunderbird site in Virginia (1974) and has associated it with a Paleo-Indian occupation (Cunningham, 1973). A nearby butchering station also has been associated with a Paleo-Indian occupation. Both sites date to about 11,000 B.C.

Typical artifact assemblages found at known Paleo-Indian sites include: fluted, lanceolate projectile points; uniface, blade-like, snub-nosed scrapers; uniface side blades; gravers; and other blade and flake tools. Evidence from known occupation sites indicated that individual sites were occupied temporarily or seasonally over a long period of time.

Paleo-Indian occupation sites have been found on sandy alluvial hillocks at elevations of about 100 feet above major river valleys as well as on upland flats. Ridge tops, being presumed routes of travel for people as well as game, have potential for Paleo-Indian sites. Saline springs and salt licks on terraces attracted large herbivores, serving to draw in the big game hunting Paleo-Indians. Salt licks have been associated with coal formations (Cunningham 1973).

Remains of Archaic cultural groups have been found in the Appalachians. Projectile points, chipped flint hoes, flint scrapers, drills, and fragments of faceted hematite have been recovered.

The later Archaic sites contained evidence of increasing dependence on grain and vegetables as food sources. Pigweed and goosefoot may have been cultivated. Bowls of the mineral steatite were made prior to the introduction of vessels made of clay. Grave offerings and red ochre often accompany burials.

Late Adena sites contained evidence of cultural influences from groups to the north and west, known as Hopewell cultural groups. Mounds covered log tombs in which one or more burials had been placed, and many tombs were destroyed during the later construction of a mound. Grave goods included ornamental offerings such as effigy pipes, pendants, gorgets, copper bracelets and rings, and grooved stone tablets. Late Adena houses were of double post side wall construction.

In the period between 900 and 1700 A.D., the Fort Ancient people lived in large, compact villages surrounded by stockades, with rows of rectangular houses. The villagers farmed corn, beans, and squash. Burials were no longer made in mounds. The dead were placed in pits inside the villages or inside house walls. Artifacts included small, triangular projectile points, drills, scrapers, blades, hoes, celts, awls, fish hooks, bird bone flutes, shell beads, ear plugs, and pottery vessels and pipes. Some late Fort Ancient sites contained European trade goods.

Settlers arrived in Appalachia during the 1700s. Cultural resources related to first permanent settlements, pioneer settlers, Revolutionary War forts, Civil War battles, and Civil War hospitals have been identified in the study area and are recorded by the state historic preservation offices.

T. ECONOMIC IMPORTANCE OF EXISTING LANDSCAPE AND ENVIRONMENTAL QUALITY

The natural environment is the key defining feature of the study area. The rugged terrain, the vast mixed hardwood forests, the narrow river valleys and the extensive coalfields have profoundly shaped the culture, economy, and quality of life of the region's residents. The land provides the livelihood, and forms the basis for a way of life for much of the population. This section provides an overview of some of the ways in which the landscape and quality of the natural environment play a role in the economy and quality of life in the study area.

1. Outdoor Recreation and Tourism

The tourism and travel industry represents a major component of the study area's economy. As an industry, tourism encompasses a variety of the other employment and industrial sectors, such as wholesale and retail trade, services, amusement and recreation. Tourism and travel businesses directly include: public and private campgrounds; hotels; motels; restaurants; gift shops; service stations; amusements; and other recreation facilities. Tourism is an export industry in the sense that it brings outside money into the regional economy. Also, tourism spending by the region's residents benefits the regional economy compared to the alternative of residents traveling elsewhere for recreation. The tourism industry produces an indirect positive effect on all economic sectors of the study area.

Resident and non-resident tourists travel to various outdoor recreational sites throughout the study area for camping, hiking, fishing, swimming, canoeing, hunting, boating, and sight seeing. In addition, tourists are also drawn to the many visual, cultural, and natural amenities found throughout the study area. For example, within the study area in West Virginia alone there are approximately 15 state parks and forests, in addition to 10 designated wildlife management areas for hunting and fishing.

RESIDENT AND NON-RESIDENT TOURISTS TRAVEL TO VARIOUS OUTDOOR RECREATIONAL SITES THROUGHOUT THE STUDY AREA FOR CAMPING, HIKING, FISHING, SWIMMING, CANOEING, HUNTING, BOATING, AND SIGHT SEEING.

There is a positive correlation between environmental quality and tourism growth. Most national and international tourism experts believe that a clean and healthy natural environment is an essential ingredient for tourism growth in both urban and rural areas (World Travel and Tourism Council 2000).

Tourism revenue information was not available by county or as a subgroup of any state; therefore, the specific significance of tourism to the study area cannot be put in numeric terms. The importance of outdoor oriented tourism to each individual state is discussed below.

a. Kentucky

According to Kentucky's 1995 Outdoor Recreation Plan, "...tourism is one of Kentucky's top industries: the third largest revenue producer, and the second largest private employer (Commonwealth of Kentucky, 1985). The Kentucky Tourism Development Cabinet reported that tourism and travel contributed 7.4 billion dollars to the state's economy in 1997, and is the state's second largest private employer, providing 146,738 full time, year round jobs. According to the Kentucky Department of Travel, visitations to Kentucky's state parks increased slightly from 8.66 million in 1996 to 8.72 million in 1998 (Department of Travel, 1999).

The Kentucky portion of the study area is located in the tourism region that the Kentucky Department of Tourism names the "Eastern Highlands." Tourism and recreational activities in the this area relate to the scenic beauty of the Appalachian Mountains. A significant attraction is the Daniel Boone National Forest, which includes the Red River Gorge. The Red River Gorge is a unique landscape containing unusual flora, which is surrounded by more than 80 natural arches sculpted by wind and water for 70 million years. The Red River is Kentucky's only National Wild and Scenic River. Another significant attraction in the Eastern Highlands is the Cumberland Gap National Historic Park. This 20,305 acres area of wilderness is the largest National Historic Park in the country.

The 1997 state average for foodservices and accommodations sales per capita (in thousands) was 1.04. Boyd, Perry and Rowan Counties had higher sales per capita than the state average (1.38, 1.11, and 1.09, respectively). Laurel and Whitley counties were just below the state average (1.02 and 0.98, respectively). This suggests that these five study area counties may be tourism destinations. The five counties mentioned all contain major transportation corridors and/or tourist attractions. Rowan County contains Cave Run Lake, a popular tourist destination, as well as the Red River Gorge. Morehead State College is also located in Rowan County, and I-64 bisects the county. The Daniel Boone Parkway terminates on I-80 in Perry County. The city of Hazard is also located in Perry County.

Whitley County is located along the Kentucky-Tennessee border, and Laurel County is located just north of Whitley. I-75 bisects Laurel and Whitley counties, and the Daniel Boone Parkway terminates on I-75 in Laurel County. The Laurel and Whitley county area also contains the Daniel Boone National Forest and Cumberland Lake.

Boyd County, located along the Kentucky-West Virginia and Kentucky-Ohio borders, contains a section of I-64. However, the oil refinery industry located in Boyd may also be responsible for the higher than average accommodations and foodservices sales in the county.

b. Tennessee

According to the Tennessee Department of Tourism Development (Department of Tourism Development, 1999), "Tennessee's 8.5 billion dollars tourism industry, drawing almost 40 million visitors in 1997, is a major economic factor for a majority of Tennessee's 95 counties." The importance of Tennessee's outdoor recreation facilities, and their relationship to the state's tourism industry is exemplified in the 1995 Tennessee State Recreation Plan: "Parks and recreation programs and facilities are vitally important to local economies. Leisure programs provide an economic stimulus that in some communities is the driving economic force and the anchor of the tourism

industry"(State of Tennessee, 1995). Some of Tennessee's most valuable outdoor recreation areas are located in the study area, particularly on the coal bearing Cumberland Plateau. Fall Creek Falls State Resort Park, which is partially located in the west central portion of Bledsoe County, "is one of the most scenic and spectacular outdoor recreation areas in America" (Department of Environment and Conservation, 1999).

The 1997 state average for foodservices and accommodations sales per capita (in thousands) was 1.26. All the study area counties were below the state average. Cumberland County was the closest to the state average with sales per capita of 0.92. Route 40, which connects the major cities of Nashville and Knoxville, runs through Cumberland County. Cumberland County's higher sales in comparison to the other counties may be related its location. The other study area counties do not appear to be tourism destinations.

c. Virginia

Tourism is one of Virginia's largest industries and is the third largest retail industry Virginia Department of Conservation and Recreation,(Virginia Tourism Corporation, 1999). Park visitation has a profound effect on the state and local economies. According to the 1996 Virginia Outdoors Plan, day use park visitors spend approximately 16 dollars per day, which amounts to a 68 million dollars contribution annually to Virginia's economy (Virginia Department of Conservation and Recreation, 1996)." The number of annual visitations to Virginia's state parks has risen in recent years.

As stated in the 1996 plan, outdoor recreational activities are vital to Virginia's rural economies: "Outdoor recreation also offers much in the way of supplemental income and small-business opportunities to entrepreneurial residents of rural communities, including: land-leasing for hunting, hunting preserves and hunt clubs, fee-fishing…. Economic development and tourism officials in rural Virginia are increasingly aware of the economic potential associated with promoting outdoor recreational opportunities and related services."

A popular tourist attraction located in the study area is the Blue Ridge Parkway. The parkway, which is one of the nation's premiere scenic roads, is being impacted by the effects of urban development. Overlooks that once provided scenic views of forests and rolling agricultural land are now revealing factories and residential developments. As emphasized in the 1996 plan, "This increasing encroachment will impact the quality of visitors' recreational experiences."

In 1997, all of the study area counties had significantly lower sales per capita in comparison to the state average for accommodations and foodservices. This suggests that none of the study area counties are tourism destinations.

d. West Virginia

The Bureau of Business Research at West Virginia University estimated the total economic impact of travel and tourism in West Virginia at 2.54 billion dollars in 1991. Employment and payroll were estimated at 49,665 persons and 535 million dollars, with another 116 million dollars in state tax revenues (West Virginia University, 2000). The economic impact of outdoor recreation activities is gaining increased recognition among West Virginia's state and local officials. Tourism, in particular, has been identified as one of the state's target industries in its strategic plan for economic development (WVSCORP, p. 38).

In 1999 the West Virginia Division of Tourism studied the impacts of "domestic leisure visitation" on the state for a five year period from 1993 to1998. The results of that study indicate that the number of visitors and length of their stays have increased overall from 1993 to 1998. The increase in length of stay from 1993 to 1998 was 7.1 million days, and the total visitors to the state increased by 2.3 million people (Department of Tourism, 1989). This study also indicates a 21% increase in direct revenues from tourism spending between 1997 and 1998, a significant increase which is reflects of the growing importance tourism has on the economy.

West Virginia's tourism industry is highly dependent upon its natural resources and scenic beauty. According to the state's 1993 Statewide Comprehensive Outdoor Recreation Plan (SCORP), the most popular activity among non-resident visitors is sightseeing, followed by visiting national and state parks, attending fairs and festivals, visiting cultural sites, hiking, rafting, camping, hunting/fishing, golf, and skiing (State of West Virginia, 1983).

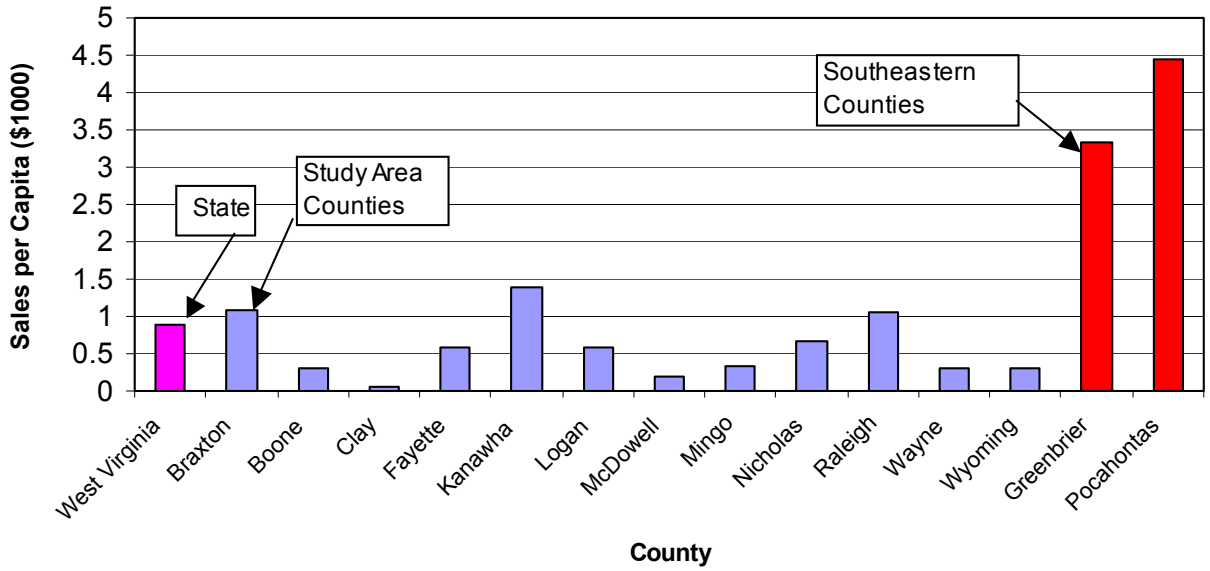
Outdoor recreation activities are closely entwined with natural resource preservation. A very large proportion of the study area's outdoor recreation experiences are highly dependent upon the quality of the natural environment. To quote promotional materials used by the Southern West Virginia Convention and Visitors' Bureau (1999), "The mountains, as we refer to them, of southern West Virginia call out to your inner soul. Their rivers offer the best whitewater rafting east of the Colorado and scenic hiking, biking and rock climbing trails abound". Development activities threaten this valued environment through effects such as diminished scenic viewsheds and degraded water quality.

Within the study area in West Virginia there are approximately 15 state parks and forests, in addition to 10 designated wildlife management areas for hunting and fishing. Whitewater rafting, hunting, and fishing are drawing increasing numbers of tourists to southern West Virginia. These activities can only take place in the proper setting, thus further emphasizing the importance of maintaining these settings to draw tourists to the area. About 250,000 whitewater rafting enthusiasts raft West Virginia waters each year. In southern West Virginia the New River is an important rafting resource, named by the AAA Mid-Atlantic Tour Book as a world renowned whitewater rafting location.

In 1998 hunting and fishing generated over 15.5 million dollars in license sales, and of those licenses about 308,000, or roughly 27 percent were sold to non-residents (Department of Tourism, 1989). Based on West Virginia Division of Wildlife Data, the study area portion of the state is not the highest revenue generating area for hunting and fishing license sales, however, the location of sale is not necessarily the location of the hunting and fishing activity.

In general, the study area counties have much lower sales per capita in the foodservices and accommodations sector than the two southeastern counties of Greenbriar and Pocahontas, and the state as a whole, suggesting that the study area is not a major tourism destination. West Virginia has an average sales per capita of 900 dollars in the food services and accommodations sector. The average sales per capita for the study area counties is 620 dollars (U.S. Bureau of the Census, 1997). In contrast, Greenbriar and Pocahontas counties had sales per capita of 3,340 and 4,440 dollars, respectively.

Figure III.T-1
West Virginia Food Services and Accommodations Sales Per Capita, 1997



Two study area counties, Kanawha County and Fayette County, have somewhat higher sales per capita in foodservices and accommodations. Kanawha has sales per capita of 1,380 dollars and Fayette has sales per capita of 1,740 dollars (U.S. Bureau of the Census, 1997) [see Figure III.T-1]. The higher sales in these counties may be due to several factors. Kanawha County contains the city of Charleston, the state capitol of West Virginia. Interstate 64, Interstate 79, and Route 77, the West Virginia Turnpike, and the Kanawha River, a tourist destination, all run through the county as well. Fayette County also contains a section of the West Virginia Turnpike, as well as Amtrak. The New River Gorge National River is primarily located in Fayette County as well.

2. Non-traditional Forest Products

POPULATIONS IN THE APPALACHIA REGION RELY UPON THE NATURAL ENVIRONMENT FOR A RANGE OF ACTIVITIES INCLUDING THE HARVESTING OF NON-TRADITIONAL FOREST PRODUCTS AND SUBSISTENCE GARDENING.

Populations in the Appalachia region rely upon the natural environment for a range of activities including the harvesting of non-traditional forest products and subsistence gardening. Both activities are more difficult to document than traditional economic activity, however, a growing amount of research shows a significant reliance upon these activities. There is a cultural tradition in the region of reliance upon the harvesting of non-traditional forest products and subsistence gardens rather than welfare or other public assistance. This reliance upon the natural environment becomes part of a work ethic of sorts which centers around frequently isolated and tightly knit communities. "Phoebe Fields, raised her [family of 17] practically herself, growing most of their own food,… none of [the] siblings has ever received government assistance" (Wenger 1998). A recent study from the West Virginia University found that environmental concern was highest in the most rural, low educated, nonprofessional population in the state (Ward 1999). This type of result reflects not only reaction to the mining industries, but also concern for their livelihood.

Estimated to account for 970 million dollars of a global market worth over 60 billion dollars (Hammett and Chamberlain 1998) the market for non-traditional forest products is estimated to have grown "by nearly 20 percent annually over the last several years". Non-traditional forest products include sassafras, ginseng, goldenseal, mayapple, slippery elm and other botanical products which can be harvested in the Southern Appalachia region. The market specifically for "wild" ginseng can be worth between 350 to 500 dollars per pound dried, as compared to so called "tame" ginseng harvested in other regions of the country worth roughly 25 to 50 dollars per pound (Hufford 1998). In the Appalachia region specifically, the harvesting of non-traditional forest products contributes a significant amount to the local economy. In 1995, non-traditional forest products contributed an estimated 35 million dollars to Virginia's economy (Hammett and Chamberlain 1998).

The natural environment, specifically small patches of rich soils, further contributes to the livelihood of people within this region. This region is not known for its prime farmland, however, small patches of good soil too small to be documented in traditional surveys, occur in the mountains of Appalachia. According to Mary Hufford, of the Library of Congress, official sources with the Soil Conservation Service report "as much organic matter as any prime farmland in the midwest occurs in Appalachia. Land is used for community and private subsistence gardening.

Much of the knowledge about non-traditional forest products, including folk medicine, or "home remedies," is passed down from generation to generation as a part of family traditions. The populations in this region also have an unusual relationship to the land itself. Much of the land from which non-traditional forest products are harvested is owned by private landowners. (Hammett and Chamberlain, 1998) A history of public admittance to this land is referred to as "the commons" or "the mountains," by which the population traditionally had understood access to the land.

Frequently, colloquial place names given to the landscape of these commons reflects an oral history of land use and community settlement. In a letter to the West Virginia Governor's Taskforce, Mary

Hufford writes, "Through continuous use of this commons . . . residents have kept alive a history reaching back to pre-Civil War settlement. Place names and stories attached to ridges, knobs, hollows, homeplaces, cemeteries, rock shelters, newgrounds, roads and trails scattered all over 'the mountains' keep this heritage alive" (Hufford, 1998).

This identity with common geography creates a culture that is closely tied to mountains, which are by tradition a common asset. In a public comment letter, West Virginia resident Al Justice writes, "Unlike the plains of the Midwest, mountain farmers and miners were accustomed to living within their environment. Integrated so closely to the cycles of nature in the mountains, they were in fact part of the mountains in both humanistic and environmental terms" (Justice, 1999).

The harvesting of forest products is also linked to social activity in the region. In the springtime throughout Southern Appalachia a number of feasts and community gatherings center around the collection of ramps, (wild leeks, *Allium tricoccum*) which are the first of the wild foods able to be harvested. "Historically, in these mountains, female sociality has flourished around the gathering and processing of greens and other wild produce." (Hufford, 1998) These spring festivals allow Appalachian residents to display and reinforce their cultural heritage by sharing music, stories, and handicrafts, such as basket weaving and quilting (Appalachian Tales, 2000).

In recent years, the evolution of mining practices from underground to surface mining has affected the public's relationship to "the commons." Historically, underground mining operations allowed for surface land uses such as gardening or wild gathering to take place. Surface mining operations, by nature, do not allow for concurrent alternate land uses. Therefore, private landowners have increasingly begun to close off these lands to the public. This has a deep cultural as well as economic impact upon the communities in the region.

U. SOCIAL AND CULTURAL CONNECTIONS TO COAL MINING AND THE NATURAL ENVIRONMENT

Coal mining practices have profoundly affected the communities and residents of the Appalachian coalfields since coal mining first commenced in the region. Sections III.U.1. through III.U.4. provide an overview of the past and current interaction between the coal mining industry and the residents of Appalachia.

Appalachian coalfield residents have a unique social and cultural connection to the natural environment. For coalfield residents, the quality of the natural environment is important both as a source of income and an integral element of Appalachian culture. Sections III.U.5. and III. U.6. present an overview of the relationship between the natural environment, Appalachian culture, and coal mining.

IDENTITY WITH COMMON GEOGRAPHY CREATES A CULTURE WHICH IS CLOSELY TIED TO MOUNTAINS, WHICH ARE BY TRADITION A COMMON ASSET. IN RECENT YEARS, PRIVATE LAND OWNERS HAVE INCREASINGLY BEGUN TO CLOSE OFF THESE LANDS TO THE PUBLIC, HAVING A DEEP CULTURAL AS WELL AS ECONOMIC IMPACT UPON THE COMMUNITIES IN THE REGION.

1. Company Town Social Environment

Today, the company town structure has largely disappeared across Appalachia. Throughout the 20th century, however, company towns played an important role in the life of Appalachian residents. "Social Control, Social Displacement and Coal Mining in the Cumberland Plateau, 1880-1930", written by Dr. James B. Jones, provides a general overview of company town structure. Selected passages are presented within this section.

While company towns existed in many parts of the United States in the first half of the 20th century, the effects of coal company towns in the Appalachian Mountains were more far reaching. The mining company controlled nearly every essential aspect of community life, from work, to shopping, education, retail merchandising, and medical care.

The social structure of these company towns was impacted by the paternalistic nature of the relationship between the company and the residents, resulting in a highly dependent relationship for the residents. Research indicates that this typical company town relationship has both psychological and physical manifestations. The nature of company towns has been documented across numerous industries; however, the relative isolation of the communities, the predominance of the coal industry and the relative poverty of the region prior to industrialization all arguably contribute to a more pronounced community structure based on company paternalism.

Despite the varying quality of the provided infrastructure, it was frequently much needed in the isolated communities of Appalachia. With the withdrawal of the coal company from a local community, infrastructure is abandoned. In some cases the impact is visual, such as dilapidated, abandoned housing; however, in other cases, it has a direct effect on the quality of life of the residents such as lack of potable water or the closing of local schools. In addition to the lack of physical infrastructure, the paternal role of coal companies extended to the maintenance of these

systems. Local communities frequently do not have a civic structure in place to take-over the maintenance of public infrastructure systems. One community member from McDowell County, West Virginia described the abandoned water system in her community as follows: "There'd be worms coming out of your spicket… The only thing we use our water for is to clean… We don't cook with it. We don't drink it. We haul all our water from a mountain spring." (Beyond Measure 1995)

Researchers looking at typical coal mining communities, specifically company towns, have noted a number of social themes in the development and mentality of residents including a sense of resignation, and feelings of lack of mastery in individuals lives. It is a logical progression that residents living in communities commanded by one powerful group should feel a lack of control over their own lives. This feeling of lack of control and mastery in both an individual and collective sense leaves the community as a whole ill-prepared to cope with the decline in the coal industry and specifically the shut-down of the local mines.

Herman R. Lantz studied a typical coal mining community in Pennsylvania at the middle of the century. An important reason this particular town was chosen was the experience of rapid development and significant economic decline related to the coal industry. Lantz's research clearly indicated that the residents lacked the motivation and even an aversion to taking advantage of new opportunities and enterprise; they had a feeling of "resignation" (Lantz 64). Lantz concluded that this resignation was only partially due to the social framework of the company-resident relationship. He attributes this phenomenon in part to the nature and culture of the people who settled the area. Pre-industrial settlers came from impoverished and marginalized populations in Western Europe. These populations were predisposed to feelings of aversion to social change (Lantz 1964). The experience of the mine workers, the boom and bust cycle, fed into an overall fear of industrial change and feelings of inadequacy in terms of coping with that continuous change. "…The many years of tenuous living associated with mining foster in the miner futility about his having any control over his life or his destiny." (Lantz 1958).

The phenomenon of lack of motivation and feelings of hopelessness has been documented on a more individual level as well. Research done in a small community impacted by a plant closing, (the Radio Corporation of America plant) indicated that the majority of the displaced workers agreed with the statement: 'No matter what I do it will be near impossible to find a job in the months ahead.' (Perrucci, et al. 1985). Lantz research suggests that in fact, when faced with new opportunities "It is difficult for the people to maintain consistent interest in almost any enterprise, since they have serious doubts about things turning out well for them." (1964).

A decline in the physical state of the community creates a downward spiraling effect on the economic plight of the local residents as well. As described previously, coal companies frequently built and maintained local infrastructure, from housing to plumbing and even churches, in the coal towns of Appalachia in varying degrees of quality.

2. Evolution of Unions in the Coal Mining Industry

Conditions leading to and necessitating the bituminous fields' unionization were many and sufficient to inspire the formation of a national union. While the coal field unions of Pennsylvania and the Midwest were organized effectively within a few decades of the United Mine Workers of America. (UMWA) formation in 1890, those of central Appalachia, specifically eastern Kentucky and West Virginia, were far more difficult to incorporate into the union holdings (Lockard 1998). Miners in these areas lived largely in company towns tucked into isolated hollows between hills, bound by contracts which guaranteed the loss of their jobs and homes should they participate in union activity; unionization was branded "socialist" and "communist" by mine owners, who claimed that union demands would break company banks and make mining unprofitable–and therefore impossible (Scott 1995, Kahn,1973).

It was during the first third of the twentieth century in general that struggles between the miners and the coal companies in central Appalachia escalated to the status of "Mine Wars". The sub-cultural identity and unity based on class consciousness which company town living fostered led miners to rise up in conflicts with coal company operators, staff, and agents; the Paint-Cabin Creek War of 1912-1913, the Mingo-Logan Mine War of 1919-1921, and the Northern Coal Field War of 1925-31, all in West Virginia, followed by the Harlan County, Kentucky, strike and violence of 1931-1939, were all examples of protests for local miners' demands which turned into miner-company clashes violent and ugly enough to draw national attention (R. Lewis 2000). "War" was an accurate name for the situation; Appalachian communities suffered greatly at the union-operator impasse.

The election of Franklin D. Roosevelt in 1932 ushered in a new era for labor unions in the U.S. The UMWA rode the wave of rank-and-file union drive to a new high of union membership, and by September of 1933, more than 90% of the bituminous coal mines in the U.S. worked under UMWA agreements (Singer, 1996).

3. Mechanization of the Coal Mining Industry

As the unionization was changing work conditions in the mines, the characterization of mining methods was also profoundly changing work conditions in the mines and social conditions in the coalfields. Today , coal mining is characterized by relatively high-paying but less abundant jobs. For example, from January 1987 to December 1996, roughly one out of every two mining employees lost their jobs in southwestern Virginia. In Dickenson County, mining employment decreased by more than half in a two year period from 1,401 workers in 1993 to 694 at the end of 1995 (Mooney 1998). Many of the jobs that remain are specialized, skilled labor positions. A Virginia Center for Coal and Energy Research study concluded that the future coal industry will be "a highly technical, highly mechanized industry run by just a few very skilled individuals who are going to be very well compensated" (Mooney 1998).

Inside the mines, there are fewer workers and job descriptions have become increasingly specialized. Since miners are no longer trained to do most jobs in the mine, their ability to share work or assist a co-worker is eliminated. The shift to skilled and specialized labor meant a shift to a commuter workforce and away from the company town system.

4. Local Culture and Ties to the Natural Environment

There is a great deal of literature and study on the distinct way of life known as the Appalachian culture. The nature of the Appalachian culture has shaped the manner in which company town residents react to the loss of jobs and community. While some scholars debate the beginnings of this unique culture, most agree on the common traits of which it is composed. Appalachians are thought to be pioneering in nature, strong, independent and resilient. Appalachian women in particular are considered hardier and more resourceful out of necessity; one local to Whitesville, WV referred to them as "Iron Weed" women (Judy Bonds, December 2000). Anecdotal evidence suggests that the female employment in Appalachia has been more widely accepted historically than in the rest of the country, again a phenomenon born of necessity. Based on these traits, the company town residents are well prepared to face situations of economic hardship.

In some cases however, the independent nature of the culture has made the transition from coal mining jobs to a more diversified and frequently less skilled job market difficult. Traditionally, men working in the mines held on to their independent nature within the workplace largely until mechanization. Anecdotal evidence also suggests, that many Appalachian men have more difficulty than women accepting lower-skilled and frequently lower-paying jobs in replacement of the coal mining jobs (Judy Bonds, December 2000). The loss of employment is a statement about a man's traditional role as breadwinner, whereas, a woman would be more significantly impacted by her inability to care for her family and children (Perrucci, etc. 1985) (Broman, etc. 1990). Social research into the impacts of unemployment also show that men are often more susceptible to depression related to job loss than women.

The cultural ties to the Appalachian region are also strongly seen in discussion of population migration as a result of mine closures. As families disperse, frequently it is understood that given time they will return to Appalachia. Migration is thought to be temporary. (Montgomery, 1968). While this is frequently not the case, it demonstrates the psychological ties that remain. The wife of a miner, trapped by poverty and her husband's black lung illness in Cincinnati said, "Maybe there's some way we can find to make it, to survive. If we find a way, I imagine we'll go back home to Kentucky and just stay there until we die." (Chandler, 1973). Part of the belief that migration is temporary stems from the typical boom and bust cycle of mining work. When a local mine is shut-down, there is a period within the community when residents still believe it will re-open despite repeated and clear signs from the companies. Initial migration is thought to be temporary until the mine re-opens; however, ultimately this is not the case. "People had been through the boom and bust cycle so many times that they just said… go on down to North Carolina and get you a job for a little while. And then, when they open up the mines back up you can come home and work… For about a year, people kinda kept that hope alive." (Beyond Measure, 1995)

V. RELATIONSHIP OF SURFACE MINING AND AIR QUALITY

1. Discussion of Study Area Air Quality

Surface mining involves a number of activities that can impact air quality or generate noise. Blasting activities are a particular concern in that they can produce particulate matter, fumes, and potentially damaging low-frequency noise and pressure waves. Basic equipment operation in the disturbed areas of mine pits, backfill areas, and haul roads can generate airborne particulate matter. Wind passage over open areas of mine sites also produces airborne particulate matter. Truck haulage of coal on public roads is also a source of particulate matter. Applicable statutory provisions are summarized in the human and community programmatic review presented in Appendix B. Performance standards for the protection of air quality are also discussed in Appendix B.

There are 42 monitoring stations located in the study area. Except for ozone levels, monitoring stations in the study area reported good air quality for all criteria air pollutants. Stations monitoring ozone concentrations in Boyd and Greenup Counties (KY) reported multiple years where levels exceeded EPA air quality standards.

2. Effects of Blasting on Air Quality

Potential health risks of airborne dust and fumes from blasting and other mining operations generally result from inhalation of particulate matter, fugitive dust, and re-entrained dust emanating from the mining operations. Fugitive dust usually refers to the particulate matter that becomes airborne due to the forces of wind and is not emitted from a stationary source such as a stack. Re-entrained dust is that which is put into the air by vehicles driving over dusty roads.

A study was recently completed by the Department of Mining Engineering at West Virginia University which included the study of dust and fume emissions from 10 blasting events at three mines. The results of this initial study indicate that detectable concentrations of respirable dust, total dust, nitrogen dioxide, nitric oxide, carbon monoxide and ammonia were found in ambient air at locations both in close proximity to the mining operation and at a distance greater than 1,000 feet from the blasting operations. Although specified in the Work Plan, crystalline silica measurements were not performed as a part of this study. Crystalline silica monitoring is needed to evaluate potential health risks associated with silicosis.

A significant reduction in detected concentrations of measured contaminants was found when the distance from the blasting operations was increased. This investigation was concerned with fugitive dust and fumes and investigators found no indication that there are any significant health risks due to exposure when no personnel are in close proximity to the blast zone. Conclusions of this investigation indicate that fugitive dust and fume emissions present no potential health problem for the following reasons:

- No event produced any "harmful" levels of any duration at distances exceeding 1,000 feet, except one measurement of 3.6 ppm NO_2 at 1,251 feet;
- The NO_2 measurement at 1,251 feet and all others were of short duration;

- Fugitive emissions are those that leave the property; if the property boundary is closer than 2,000 feet, persons within this area are evacuated.

The study included a discussion concerning four-wheel drive vehicles which can produce 75 pounds of fugitive dust per mile traveled on a dirt road (Hesketh, 1983), and that many county roads in the vicinity of a surface mine are unpaved; therefore, blasting would appear to be an unlikely source of significant dust at off-site locations.

The text of the West Virginia University Mine Dust and Blasting Fumes Study can be found in Appendix G of the EIS.

3. Effects of Hauling on Air Quality

a. On-site Heavy Equipment

Heavy equipment used during mining operations release the following criteria pollutants: nitrogen oxide (NO_x), sulfur oxide (SO_x), volatile organic compounds (VOCs), and carbon monoxide (CO).

b. Dust and Other Pollutants along Transport Roads

Hauling extracted coal from surface mines requires the use of trucks, trains or conveyors**.** The equipment used to haul the coal and other waste materials from the surface mines generates particulate from disturbance of the ground surface. Additionally, this transportation equipment also may emit NO_x, CO, SO_x and VOCs.

4. Effects of Mining on Air Quality

a. Particulates Released During Mining

Surface mining operations involve the release of particulates into ambient air during operations. Particulates can affect human health, animal health and can negatively impact crop growth. The EPA enforces National Ambient Air Quality Standards (NAAQS). There is a NAAQ standard for particulate matter sized at 10 microns in diameter or smaller, referred to as PM-10 emissions. Regulatory standards and guidelines for airborne dusts and fumes are further discussed in subsection 7 of this section.

b. Crystalline Silica

One issue of particular concern in the mining industry is exposure to crystalline silica. Workers in both surface and subsurface mining operations have the potential to be exposed to crystalline silica. Surface mine workers operating highwall drills, end loaders, dozers and trucks on mine property have a high probability of exposure to silica-containing dust.

Respirable dust disease, a progressive pulmonary disorder that builds up over years of inhaling high levels of airborne dust particles, is known in many forms: coal miners' pneumoconiosis, black lung disease, silicosis, and asbestosis. Government studies estimate that between 1,600 and 3,600 working miners and retirees has one of these fatal lung disorders. Ron Eller, director of the University of Kentucky's Appalachian Center, stated in the Louisville Courier-Journal, "Almost

every family in Central Appalachia has a family member who died of black-lung disease. It's as ordinary as diabetes or high blood pressure or cancer in the region" (Harris, 1998).

5. State Implementation Plans

The 1990 Clean Air Act is a federal law which covers the entire country. EPA establishes limits on primary National Ambient Air Quality Standards (NAAQS). Also under this law, States are required to develop State Implementation Plans (SIP). The SIP should explain how each state will perform activities to comply with the Clean Air Act. The SIP generally consists of a collection of regulations which the state will use to enforce the Clean Air Act. Each individual SIP is submitted to the EPA for approval. SIPs vary between states.

Air emissions associated with mining operations (such as blasting, earth and rock removal, transport-related dust) are considered "fugitive emissions" under the Clean Air Act. Thus far, mountaintop mining has not been considered to meet the criteria for major source air quality permits (Title V of the CAA), defined as sources which emit at least 250 tons/year of a regulated pollutant.

6. Regulatory Standards and Guidelines

The Environmental Protection Agency has established air quality standards to protect human health from dust and other forms of particulate air pollution. There are two National Ambient Air Quality standards (NAAQS) for dust. One standard applies to particulate matter sized at 10 microns in diameter or smaller (PM-10). In 1997, EPA also promulgated a NAAQS for particulate matter sized at 2.5 microns or smaller (PM-2.5), but there are no regulatory requirements associated with this standard as yet, and it is under litigation.

The PM-10 NAAQS pertains to all dusts that fit the aerodynamic diameter requirements. This includes the fugitive emissions which may contain crystalline silica. The NAAQS does not include specific limits on silica itself.

Air emissions associated with mining operations (such as blasting, earth and rock removal, transport-related dust) are considered "fugitive emissions" under the U.S. Clean Air Act (CAA) and the federal government generally does not have the authority to regulate fugitive emissions which are not associated with a permanent stationary source. Thus far, mountaintop mining has not been considered to meet the criteria for major source air quality permit (Title V of the CAA), defined as sources which emit at least 250 tons/year of a regulated pollutant. The West Virginia air pollution control program does not currently require best management practices nor does it issue air permits to mountaintop mining operations although the Surface Mining Control and Reclamation Act of 1977 (SMCRA) indicates mining permits may contain control practices for some fugitive emissions.

NIOSH has developed criteria documents pertaining to occupational exposure to respirable coal mine dust. The Recommended Exposure Limit (REL) established by NIOSH for exposure to respirable coal mine dust is 1 milligram per cubic meter of air. The NIOSH REL for occupational exposure to crystalline silica is 0.05 milligrams per cubic meter of air. The REL represents the upper limit of exposure for a worker for up to a 10-hour workday during a 40-hour work week. The NIOSH publication: Criteria for a Recommended Standard for Occupational Exposure to Respirable Coal Mine Dust, dated September 1995, contains historical sampling data for both surface and

underground mines. These tables provide useful information concerning occupational exposures and may provide some insight into potential residential exposures for the sampled mines.

The Mine Safety and Health Administration maintains separate air monitoring requirements for mining operations and the requirements are designed to protect mine workers. The Permissible Exposure Limit for respirable coal mine dust adopted by MSHA is 2 milligrams per cubic meter of air. This standard is reduced when the content of respirable quartz (crystalline silica) in the coal dust is greater than 5 percent. Inspectors for MSHA have the authority to inspect each surface mine at least twice a year. MSHA inspectors collect both personal and area air samples for each mechanized mining unit. Area air samples at the intake of the mine are collected periodically. The location and type of samples collected by the MSHA inspector are based on several things, including the adequacy of the mine operator's dust control measures.

Coal mine operators are required to collect five respirable occupational exposure samples in each mechanized mining unit for each bimonthly sampling period. Additionally, the operators are required to collect work area air samples. MSHA requires that coal mine operators submit a "Ventilation System and Methane and Dust Control Plan" every six months. This plan must include information about ventilation equipment and operating parameters for dust control. Once again, most of the requirements pertain to the protection of the coal mine workers rather than the residential population living in the vicinity of the mine.

The World Health Organization (WHO-1986) recommended a "tentative health-based exposure limit" for respirable coal mine dust with less than 7 percent respirable quartz. This information is cited in the NIOSH Criteria for a Recommended standard document referenced above. According to the NIOSH reference, the risk of disease when using the WHO approach could be determined separately for each mine or group of mines.

Most established exposure limits for all of the potential contaminants associated with surface mining apply only to exposure in an occupational setting. The following is a list of references with exposure limits established for the "general population:"

- The Department of Energy has established Temporary Emergency Exposure Limits (TEELS) for over 1250 chemicals
- The California Environmental Protection Agency has established Recommended Exposure Limits for use in comparison of monitoring or modeled air contaminant concentrations
- EPA has established Acute Emergency Guidance Levels (AEGLS)
- The National Academy of Sciences has Short-term Public Emergency Guidance Levels (SPEGLs).

7. Potential Health Risks

Potential health risks of airborne dust and fumes from blasting and other mining operations generally result from inhalation of particulate matter, fugitive dust and reentrained dust emanating from the mining operations and hauling. Impacts to air quality are localized within the immediate area of the mining site. Increased awareness of the dust emitted from hauling operations in recent years has improved air quality problems associated with hauling in the vicinity of the mining operations.

In order for a negative health effect to occur, a complete exposure pathway must be in place. A complete exposure pathway exists if there is, (1) a source or chemical release from the source (i.e., fugitive dust and fumes and chemicals in these sources), (2) an exposure point where contact with the chemical can occur (residents coming into contact with the fugitive dust or fumes), and (3) an exposure route by which contact can occur (inhalation of the dust or fumes). If one of these components is missing, then the exposure pathway is considered incomplete and the potential for negative health effects is considered to be negligible (EPA, 1989).

Federal legislation has addressed the health and safety hazards associated with both surface and underground mining operations. Additionally, many state governments maintain regulatory bodies for the oversight of mining operations. Increased technology has also allowed for the use of remotely operated machinery to decrease workers' exposure to dangerous work environments, and the use of more sophisticated air monitoring equipment. Some states have implemented "free chest x-ray" programs for mine workers to provide diagnosis and treatment of work-related lung diseases.

One issue of particular concern in the mining industry is exposure to crystalline silica. Workers in both surface and subsurface mining operations have the potential to be exposed to crystalline silica. Surface mine workers operating highwall drills, end loaders, dozers and trucks on mine property have a high probability of exposure to silica-containing dust.

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Specific potential health effects associated with exposure to the fugitive dust and fumes emitted from mines are dependent on the chemical constituents of the emissions.

a Fugitive Dusts/Particulate Matter

Fugitive dust usually refers to the dust put into the atmosphere by the wind blowing over bare soil, plowed fields, dirt roads or desert or sandy areas with little or no vegetation. Reentrained dust is that which is put into the air by reason of vehicles driving over dirt roads (or dirty roads) and dusty areas. The emission rates of fugitive dusts are highly variable and dependent on the prevailing atmospheric conditions, including wind speed and direction.

Particulate matter (PM) of concern for protection of lung health are the fine particles. PM in the

form of respirable coal mine dust are particles with aerodynamic diameters less than 10 microns. This size of airborne dust is capable of entering the lungs if inhaled. According to the American Lung Association, particles of special concern are less than 2.5 microns in diameter. These particles are more easily inhaled than larger sized particles and can either become embedded deeply into the lungs or absorbed into the bloodstream.

Inhalation of particulate matter air pollution is particularly harmful to sensitive members of the population who have pre-existing conditions such as asthma and chronic obstructive pulmonary disease. Inhalation of particulate matter containing respirable coal mine dust may lead to a condition called coal workers' pneumoconiosis. This condition is prevalent in coal mine workers who have worked in underground coal mines for a period of eight years or longer. Chronic bronchitis, emphysema and decreased lung function are also prevalent among coal mine workers. Pneumoconiosis is a general term used to describe lung diseases which have resulted from the inhalation of dust, usually inorganic (rock or mineral) dust.

Another form of pneumoconiosis associated with coal mining is silicosis. The inorganic dust exposure which causes silicosis is respirable crystalline silica. Silicosis is a nonreversible lung disease caused by inhalation and retention within the lungs of silica dioxide crystals. Silica is the second most common mineral in the earth's crust and a major component of sand, rock and mineral ores. In addition to silicosis, other lung diseases have been associated with inhalation of crystalline silica. These diseases include chronic bronchitis and tuberculosis.

There are three types of silicosis:

- Chronic silicosis occurs after 10 or more years of overexposure
- Accelerated silicosis results from higher exposures and develops over 5-10 years
- Acute silicosis occurs where exposures are the highest and can cause symptoms to develop within a few weeks to 5 years of exposure.

b Fumes Released During Blasting

Additional possible potential health effects associated with surface mining operations include those related to the potential inhalation of toxic fumes generated from the blasting operations. Blasting operations may involve the release of fumes including: carbon monoxide, nitrogen dioxide, nitric oxide and ammonia. The type and amount of fumes released is dependent on the frequency and type of blasting operation conducted for the particular mining operation.

Exposure to carbon monoxide causes a variety of health-related symptoms including headache, nausea, weakness and dizziness. Additionally, exposure to high concentrations of carbon monoxide results in a condition referred to as asphyxial anoxia in which there is inadequate oxygen delivery in the presence of adequate blood flow. Carbon monoxide is commonly referred to as a "chemical asphyxiant."

According to research published by the National Institute for Occupational Safety and Health (NIOSH), over the past 30 years, blasters have switched to using less expensive blasting agents such as ammonium nitrate/fuel oil (ANFO) mixtures. Ammonia is released during this combustion process. Exposure to ammonia causes eye and respiratory irritation.
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W. BLASTING AND THE LOCAL COMMUNITY

Because of the relatively close proximity of some mountaintop mining operations and populated areas within the EIS study area, blasting associated with mountaintop mining can impact local communities. Blasting activities are a particular concern in that they can produce particulate matter (dust), fumes, flyrock, ground vibrations, and air pressure waves (airblast). This section of the document focuses only on flyrock, ground vibrations, and air pressure waves produced by blasting at mountaintop mines. Air quality and potential health risk is discussed in Section V of this chapter.

1. Trends Associated With Blasting at Mountaintop Mining Sites

Blasting activities have used larger quantities of explosive materials to fracture greater amounts of coal mining overburden over the years as mining operations have increased in size and productivity. For example, the West Virginia Governor's task force reported that over the last 20 years, blast detonations associated with the larger mines have increased from approximately 100,000 pounds to over one million pounds of explosives. In addition to more explosives used in blasting, the time periods over which blasting may occur in a general location have changed. For example, as the location of a typical contour mine nears a house and passes, blasting influence may last for weeks or perhaps a few months. For a large mountaintop mine, removing multiple coal seams, the blasting near a home may last years. This occurs where numerous blasts facilitate overburden removal as underlying seams in the same location are successively mined. These trends have, in turn, exacerbated local citizens' perceived impacts of MTM/VF mining operations. Many of the comments received during scoping for this EIS dealt with concerns over impacts that were reportedly occurring to structures, water wells, and the general quality of life in communities as a result of blasting.

2. Studies Relating to the Impact of Blasting on the Community

A number of studies have been conducted over the years to determine the effects that blasting can have on traditional structures and wells. These studies were used in the development of OSM regulations, establishing thresholds for air blast and ground vibrations that would prevent injuries to persons or damage to public or private properties outside the permit area. Since the scale of blasting, as indicated above, has changed, and coalfield residents continue to allege blasting-related problems, OSM routinely evaluates the blasting control portion of the regulatory program to assure it adequately provides for protection of the public and property. For example, OSM recently performed a national review of 1,317 blasting complaints recorded over a one-year period (between July 1998 and June 1999). From readily available data in Federal and State files, collected as part of the national citizens' complaint review, the report entitled "Blasting Related Citizen Complaints in Kentucky, West Virginia, Virginia and Tennessee" was prepared (see Appendix G). The study gathered data in three general categories: (1) reason(s) for the complaint; (2) methods of investigation used in the complaint investigation; and (3) resolution of the complaint.

The following general observations are made from the study data.

- The EIS study area accounted for 54% of the blasting-related complaints nationally. If one mine in Pennsylvania (outside the EIS study area) were omitted, the EIS study area accounted for 72% of the complaints.
- Within the EIS study area, approximately 50% of the blasting-related complaints were lodged in West Virginia. Kentucky accounted for approximately 37%, with Virginia and Tennessee accounting for approximately 12% and 1%, respectively.
- Annoyance/noise concerns were a component of 75% of the blasting-related complaints in the EIS study area.
- Damage to structures (residential dwellings) was alleged in approximately 33% of the blasting-related complaints in the study area. In investigating these complaints, no instances of blast-induced vibration damage were found attributable to the mining operation by the regulatory authority.
- Alleged damage to domestic water systems was a component of approximately 14 percent of the blasting-related complaints in the study area. One of the investigations resulted in a finding of impact on water quantity or quality.
- Flyrock (earthen materials such as rock) beyond the permit boundary was alleged in approximately 2 percent of the blasting-related citizen complaints.

Investigations of blasting-related citizen complaints resulted in the issuance of a notice of violation and/or cessation order in the states within the EIS study area, as follows:

- 44 violations were issued in West Virginia in response to 30 of 352 complaints (9%).
- 36 violations were issued in Kentucky in response to 23 of 263 complaints (9%).
- 17 violations were issued in Virginia in response to 12 of 87 complaints (14%).
- No violations were issued in Tennessee in response to 6 complaints (0%).

Most of the violations were issued for exceeding vibration limits or keeping inadequate records and were generally issued for violations unrelated to the original complaint(s).

Occasionally, structures that either: 1) do not fall into the "typical" category; or, 2) may not have been included in the body of research data on which the SMCRA regulations were founded, are identified near proposed mine sites. An OSM study, entitled "Comparative Study of Structure Response to Coal Mine Blasting – Non-Traditional Structures" was designed to provide information on the impact of blasting on such structures (see Appendix G). Non-traditional structures may include pre-fabricated houses, trailers, log homes, sub-code homes and adobe structures. This study, conducted near eleven mine sites in nine states, measured the response characteristics of these structures to determine if the current rules provide for their protection, or if modified vibration limits were prudent. As in earlier studies of similar structures, this study concluded that certain types of non-traditional structures (e.g., those constructed of earth, masonry, or two story "camp" homes), responded more strongly than traditional frame or masonry structures to blasting vibrations and air blast. When these structures are present near coal mine blasting, lower site-specific limits may be a prudent action for the regulatory authority to take. This provision is currently an option for the regulatory authority that is provided within the existing regulatory program. This study provides the basis for site-specific investigations on non-traditional structures and should result in improved levels of protection for these structures.

Previous scientific research has generally not supported a connection between blasting and permanent adverse impacts to domestic water supplies (wells). The recent OSM study entitled "Comparative Study of Domestic Water Well Integrity to Coal Mine Blasting" was designed to determine if the available information on wells and impacts from blasting remained valid--considering the larger blasts that are typical in today's mountaintop mining operations. This study was conducted in southern West Virginia, eastern Kentucky, and southwestern Virginia. The study concluded that, similar to earlier studies on wells and blasting, few changes could be directly attributed to a blast event (e.g. no major differences in the observed water quality and well yield data). The study report related to blasting and water wells is under development, but an executive summary is provided in Appendix G.

3. Regulatory Standards and Guidelines

Federal SMCRA regulations related to blasting have not changed substantially since 1983. Under the SMCRA regulatory program, limitations and controls are placed on blasting with the intent of protecting public safety and limiting flyrock, airblast, and ground vibrations to prevent offsite damage to structures. The SMCRA regulatory program provides specific blasting-related performance standards that must be complied with when conducting mining operations. Mine permit applications are required to contain a blasting plan detailing the measures to protect surrounding areas from damage and adverse effects. The general public is notified of proposed mining activities by an advertisement placed in local newspapers at the time of the permit application. This plan can be reviewed by the public during the public comment period and discussed at public meetings.

The Federal rules require that all persons directly responsible for use of explosives on a mine site be trained and tested through a program that includes a written examination and demonstration of field experience. At a minimum, the training and testing includes the technical aspects of the blasting operations and State and Federal laws governing the storage, transportation and use of explosives. A certified blaster may utilize non-certified personnel as assistants in a blasting operation only when they are under the direction of and given on-the-job training by the blaster. Certifications may be suspended or revoked if the blaster violates Federal or State laws.

Once the permit is issued, coal operators are required to place blasting schedule announcements in local newspapers prior to initiation of blasting, and to continue to do so annually as long as blasting continues. At least 10 days prior to initiation of blasting, residents and owners of other structures within one half mile of the proposed blast sites are also mailed a blasting schedule. The blasting schedule mailing is required annually as long as blasting continues. The schedule outlines the location of proposed blasting, the dates and time periods of blasting, and the warning signals. The SMCRA regulatory authority must approve this schedule and can limit the blasting, if necessary and reasonable, in order to protect the public health and safety or welfare.

Pre-blast surveys are offered by mining operators at no cost to (or may be requested by) residents and owners of structures located within one-half mile of the permit area. These surveys are designed to identify any sensitive structures where additional safeguards may be necessary and to document conditions of structures near the mine site prior to blasting. This provides important baseline information to facilitate the resolution of potential blasting damage complaints. A pre-blast survey typically includes written documentation, supplemented by pictures, of existing structure condition,

such as wall cracks, foundation cracks, and broken windows. 30 CFR Section 816.62 also requires that consideration be given to utilities and water systems during a pre-blast survey, however assessment of these structures may be limited to surface conditions and other readily available information. Well quantity measurements, such as pump tests or other yield estimates, are not typically included in pre-blast surveys. Copies of the pre-blast surveys are provided to both the resident and the regulatory authority.

Prior to initiation of blasting, signs warning of blasting activities must be placed at identified locations of possible public access to the site and must be maintained until blasting will no longer occur. Warning and all clear signals audible up to one-half mile from the blast site must be used in association with each blast. Access to the site prior to a blast must be controlled to prevent persons or livestock from entering the blast area. Once blasting is initiated, it must be conducted in a manner to prevent personal injury, damage to public or private property beyond the permit boundary, and adverse impacts to nearby underground mines or surface and groundwater availability outside the permit area. Specific limits on airblast, ground vibration, and flyrock are identified in regulations that will generally provide the required protections. If unique circumstances are identified in the pre-blast survey, as a result of a citizen's complaint, or through a mine site inspection, the regulatory authority can establish lower ground vibration or airblast limits to ensure prevention of damage. Detailed records of each blast must be maintained and available for review for at least 3 years.

SMCRA statutes and regulations provide a mechanism for anyone who has reason to believe that a violation of blasting or other requirements may have occurred to file a complaint with the regulatory agency. Generally, complaints are made to the regulatory agency, which will then investigate the complaint and render a written finding to the complainant. If the investigation confirms a violation, of blasting or any other requirement, enforcement action is taken against the coal operator. If citizens disagree with the findings of a complaint investigation, they have appeal rights in all four states within the EIS study area. The initial appeal is generally conducted internally by the regulatory agency. If a satisfactory resolution is not achieved in this way, appeals may proceed to civil court for judicial resolution, or though other agencies (the appeal agency varies in the individual states).

4. Recent Program Improvements

Although studies and surveys have shown current regulatory controls provide adequate protections for nearby properties/structures, SMCRA regulatory authorities recognize that blasting complaints continue at a relatively high level and are particularly contentious in the steep-slope coalfields where larger mining operations are adjacent to populated areas. While compliance records indicate that a relatively small number of blasts actually exceed performance standards, additional guidance, analysis tools, and training will increase the capabilities of inspectors and blasting specialists to further minimize blasting effects and more successfully address citizens' sensitivity to blasting issues.

OSM has several initiatives directly related to this issue. OSM recently developed and provided the Blast Log Evaluation Program (BLEP) to the state SMCRA programs as part of its Technical Information Processing System. BLEP is designed to help the mine inspectors compile blast log data to: 1) identify record-keeping problems; 2) identify unusual site conditions; 3) "red-flag" quality control problems by the blast crew; and 4) facilitate review by blasting specialists. The OSM

Blasting Guidance Manual (1987) is being rewritten to reflect the current technology and 15 years of regulatory experience on blasting. This manual not only assists in the evaluation of blasting complaints, but provides the coal mining industry with an awareness of the particular areas where regulatory focus will occur and methods for minimizing problems through blast design, controls, and monitoring techniques. Also, in addition to the basic technical training course entitled "Blasting and Inspection", the OSM National Technical Training Program has developed a class entitled "Advanced Blasting: Investigation and Analysis of Adverse Effects." This additional training places emphasis on monitoring and evaluating ground vibration and airblast to heighten the inspectors' understanding of potential adverse effects and may improve protection of nearby structures and potentially reduce nuisance impacts. The training describes the response of buildings to vibrations and teaches recognition of weather conditions when blasting would create more nuisances (e.g. days with temperature inversion). Training also explains the existing flexibility in blasting regulatory requirements that allow states to limit blasting based on site-specific conditions (i.e. use of pre-blast surveys), as well as re-evaluation of blasting limits if damage allegations arise. Increased technology transfer on the latest techniques and methods for assessment of potential adverse effects from blasting enhance the regulatory authorities' ability to:

- Monitor ground vibrations and airblast,
- Evaluate blasting records,
- Recognize unique site conditions,
- Adjust blasting plans accordingly, and
- Communicate more effectively with citizens.

West Virginia has also demonstrated a leadership role in passing laws and regulations that highlight the importance of mining companies being good corporate neighbors and addressing citizens' blasting concerns. The West Virginia Legislature and WVDEP have recently developed and implemented state statutes and regulations that created the Office of Explosives and Blasting (OEB). The OEB establishes dedicated blasting specialists and new regulatory standards including:

- For single permits of greater than 200 acres (or contiguous permits of 300 acres or more), revising the pre-blast survey requirements to 0.5 mile from the permit boundary or a distance of 0.7 mile from any proposed blasting site, whichever is greater;
- Requiring that a well water sample and yield test be part of the pre-blast survey;
- Mandating that those who conduct pre-blast surveys must be trained and certified, including a minimum of 12 hours of refresher training every three years for certified blasters;
- Implementing an improved blast damage claims process, whereby the state retains the services of independent, qualified third parties to evaluate claims of damage; and
- Developing a binding arbitration process for use if the determination of the third party investigator is challenged.

5. Conclusions

The blasting studies completed as a part of this EIS reveal that existing regulations provide appropriate controls for preventing damage to structures, including wells. OSM's recent programmatic oversight review of blasting-related citizen complaints confirmed that when blasting complaints occur, the complaints are investigated and responded to as required. The complaint study appears to indicate that, while blasting activities are noticeable by adjacent residents and often perceived to cause damage and trigger a complaint, the cases of confirmed blast-related damage comprise a small portion of total complaints. Additional research by OSM has not indicated that existing damage thresholds are inadequate. Moreover, the regulations provide for states to adjust limits in circumstances where lower damage thresholds are warranted. As such, the existing programmatic controls (statutes, regulations, policies, and guidance) provide adequate levels of protection. No additional actions to control blasting are warranted at this time. OSM diagnostic tools, training, and updated guidance should enhance application of the existing standards as well as blast monitoring and investigation of future complaints.

The agencies recognize that, in spite of enforcement of the existing regulations and implementation of the recent program improvements, blasting concerns/complaints will continue. Concerns and subsequent complaints are likely to decrease as a result of the identified recent program improvements. However, when mountaintop mining operations are near populated areas, complaints, particularly those related to noise and vibration of homes (nuisance impacts), may still occur in relatively high numbers. Although regulations provide a limited ability to control nuisance impacts (for example blasting may typically occur only between sunrise and sunset), these nuisance-type concerns will continue to have periodic adverse effects on the quality of life of residents living in close proximity to the mine sites. The regulations were designed to minimize damage potential and only indirectly address nuisance; however, citizens retain the right to take civil action against a mining operation for nuisance-related concerns. There have been court cases in the coalfields where mining activities have been ordered to adjust operational procedures (i.e., above-and-beyond existing regulatory program controls) to reduce public nuisances.

IV. ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES ANALYZED

A. INTRODUCTION

Chapter IV describes the effects on the human environment of the no action and proposed action alternatives described in Chapter II. Chapter III provides a detailed discussion on the affected environment of the study area and results of technical studies of environmental effects of mining, including MTM/VF operations. Technical information gathered for this EIS assists in delineating consequences and may also be a useful tool in the regulatory decision making process on a case-by-case basis. To give proper context to the discussion of consequences of the alternatives in this chapter, each section of this chapter sets out additional information on the consequences of MTM/VF activities.

The information on consequences of the alternatives includes the benefits of the alternatives, anticipated outcomes of proposed actions, and available information on the impacts of proposed activities regulated by the programs analyzed in this EIS. This programmatic EIS is necessarily broad given its purpose of addressing policies, guidance, and coordinated agency decision-making processes to minimize the adverse environmental effects from MTM/VF and the size and location of excess spoil disposal sites in valleys. The proposed actions and alternatives consist of many potential changes to data collection and analysis protocols, guidelines for best management practices, regulations, and mitigation requirements for MTM/VF operations. They are aimed at improving agency efficiency and effectiveness, increasing consistency within and between agencies, and meeting other public policies.

The proposed action alternatives are largely administrative and as a result, accurately projecting their environmental consequences is difficult. All three action alternatives share the goal of a better regulatory process and improved environmental protection. Therefore, projections of the positive and negative consequences of the action alternatives and the No Action Alternative must be made to compare the alternatives, even though accurately projecting impacts of administrative measures is difficult.

Environmental consequences can be categorized and presented in many ways, including the following:

- Direct effects of implementing an action
- Indirect effects, occurring in combination with other influences, that may occur at a later time or at some distance from the activity
- Short term or temporary effects
- Long-term or permanent effects
- Adverse effects
- Beneficial effects
- Cumulative effects
- Economic or social effects

This chapter discusses environmental consequences in these various ways.

1. Cumulative Effects

The Council on Environmental Quality (CEQ) regulations [40 CFR 1500-1508], implementing the procedural provisions of NEPA, define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions [40 CFR 1508.7]." "Actions," as used in CEQ regulations, may include a broad range of activities from those as specific as individual construction projects to those as general as implementing regulatory programs. Individual adverse impacts from an action may be insignificant individually, but may accumulate over time from one or more origins and collectively result in significant adverse impacts that degrade important natural resources. The cumulative impacts of a particular action can be viewed as the total effects on natural resources, socioeconomic resources, human health, recreation, quality of life aspects, and cultural and historical resources of that action and all other activities affecting those resources, compounding the effects of all actions over time.

The proposed actions and alternatives are broad in scope. As a result, this EIS is programmatic, addressing environmental consequences that are correspondingly broad in scope. Furthermore, none of the proposed actions or alternatives would be implemented in a vacuum. Implementation of the selected actions are interwoven with many other actions, events, and trends taking place at local, regional, national, and international levels.

For example, surface coal mining is not the only factor that affects vegetative cover in the study area. Land management practices, which include harvesting of timber and development for residential, recreational or commercial purposes, are also key considerations. The future of forest land in the eco-regions of the study area cannot be predicted by considering changes in surface coal mining reclamation alone.

Similarly, the CWA and SMCRA regulatory programs are not the only factors that affect coal mining and communities in the study area. Also of major importance are regional population loss or growth; changing demographics, lifestyles, property values, and alternate energy sources; economic competition and restructuring; and changing laws, policies, and practices implemented by other Federal and state agencies.

Population growth or decline and demographic changes in the study area will continue to transform communities in the study area. Communities that continue to lose population due to a lack of economic growth and diversification will further decline or be strained by decreases in employment opportunities in coal mining. However, communities that are positioned to sustain and promote economic growth through diversification will avoid a decline in growth. Demographic and land use changes might increase or decrease a community's tax base. Where economies are stable or growing, the tax base would likely be stable. Where populations continue to decline or mineral production significantly declines, the state and local tax revenues might decline.

The protection of Federally-listed species and their habitats can change the way mining activity is conducted. Future activities designed to avert habitat loss and endangered species listings will be implemented under any of the regulatory alternatives considered in this EIS.

A fundamental assumption of this analysis is that, with or without changes to the CWA and/or SMCRA regulatory programs for MTM/VF operations, the human environment within the study area will continue to change. The environmental regulatory programs for MTM/VF operations are but one factor in defining the future conditions of the human environment. The potential environmental consequences of the proposed actions and alternatives, including cumulative effects, are discussed by resource in this chapter. The surface mining of coal, including MTM/VF operations, is regulated by the laws and regulations discussed previously in Chapter II and Appendix B. None of these alternatives would reduce the effectiveness of the current regulatory programs described in Chapter II.

This EIS evaluated the cumulative effects of MTM/VF on various resources, socio-economics, and the human or natural environment in the following sections: Chapter III.N, Past and Current Mining in the Study Area; Chapter III.O, The Scope of Remaining Surface-Minable Coal in the Study Area; Appendix G, Post Mining Land Use Assessment--Mountaintop Mining in West Virginia, Mountaintop Technical Team Report, Phase I and II Economic Studies, Case Studies Report on Demographic Changes Related to Mountaintop Mining; Appendix I, Landscape Scale Cumulative Impact Study of Mountaintop Mining Operations and Figure III.O., The Extent of Potential Mountaintop Minable Coal.

2. Irreversible and Irretrievable Commitment of Resources

A resource is irreversibly committed when an action alters the resource so that it cannot be restored or returned to its original or pre-disturbance condition. A resource is irretrievably committed when it is removed or consumed. For example, in the surface mining of coal, the removal of coal would be an irreversible and irretrievable commitment of resources. While the coal would be irreversibly committed from the geologic formations, it is also irretrievably committed when burned for electrical generation.

Another example of irreversible loss involves native soil loss or erosion. Soil losses from handling, erosion losses from topsoil stockpiles, and other unavoidable erosion losses of native soils would be irreversible. CWA and SMCRA require that soil erosion and sedimentation be minimized and otherwise controlled to mitigate these effects to the maximum extent technologically feasible. Also, studies of reclaimed sites have shown that non-native mine soils, with time, become more like stable developed native soils.

The direct burial of stream segments by excess spoil for MTM/VF operations is a long-term irretrievable commitment of resources for the buried stream segment. However, the CWA and SMCRA provisions are designed to assure that adverse impacts to aquatic resources are minimized and that significant degradation of the downstream watershed does not occur from MTM/VF activities. Consequently, the effects of MTM/VF on aquatic resources are irreversible for a buried stream segment, but may produce varying levels of impact to the overall hydrologic regime depending on the watershed considered.

Impacts on terrestrial resources, such as forests and wildlife may be either permanent or temporary depending on the time frame considered. For instance, a mine site without reforestation as the post-mining land use may still result in a reversion to forestry through natural succession–despite the problems of excess compaction, lack of native seed sources across the reclaimed area, and other

conditions hostile to reforestation. With sufficient time, although it may take hundreds of years, natural processes for mine soil improvement and succession can overcome conditions limiting reforestation, and the resource loss is not irreversible. Conversely, intensively managed reclaimed mine sites may never regain trees due to long-term use as industrial, residential, agricultural, or other non-forest uses. Reclamation techniques may exist to equal or exceed natural forest regeneration and productivity. In the cases where these techniques are applied, the loss of forest resource may be no less reversible than timbering; and in some cases productivity gains surpassing forestation on native soils. Reclamation of mine sites to forest conditions (commercial or otherwise) may not reestablish wildlife habitat to pre-mining conditions. While no program can dictate post-mining land uses, many programs encourage and promote the tangible benefits for return of mined land to forest conditions so as to minimize and mitigate adverse effects.

While loss of individuals of certain species within the mined areas may be irreversible, individuals of other species may be mobile enough to relocate to adjacent interior forest tracts. The adjacent forest tracts, which include their own resident populations, may or may not be able to support the additional populations due to competition for habitat. Again, the reclamation methods employed and post-mining land uses selected will determine whether or not the loss of wildlife resources is irreversible. Researchers have debated the benefits and detriments of forest edge habitat versus forest interior habitat, centered on the concept of biodiversity. Studies have shown that a post mining change in habitat can provide transitional habitat for declining grassland species uncommon to forested ecosystems. Accordingly, a shift in wildlife resource species may be temporary in nature, as with the vegetative cover, and provide arguments both for and against irreversible change–depending on the viewpoint of the observer.

Environmental controls on surface coal mining and reclamation may render some coal resources irretrievable. Avoiding and minimizing valley fill stream impacts could make portions of coal seams recoverable only by inefficient methods or not feasible to recover at all. However, these effects may be temporary for some coal resource blocks if different mining methods become feasible or the coal market makes it economical to mine the reserves in compliance with environmental controls. That is, rising energy prices or new technology might allow reclamation techniques that currently cannot be performed within profit margins. The loss of these reserves would not have an immediate, irreversible effect on energy production, because sufficient coal reserves exist elsewhere to meet current energy demands. However, long-term effects on energy production could occur, since rendering some Appalachian surface mining coal reserves unminable could ultimately hasten reserve depletion when other coal sources dwindle.

The level of future surface coal mining and reclamation operations under the proposed actions or alternatives would directly affect the magnitude of the irreversible and irretrievable commitment of resources. Provisions of the alternatives would also define the nature and extent of these commitments. These types of irreversible and irretrievable effects are discussed as part of the environmental consequences of the alternatives for resources susceptible to such effects.

B. AQUATIC RESOURCES

This section addresses the environmental consequences of MTM/VF associated with the alternatives as they affect the aquatic resources. These consequences include direct impacts such as the physical loss of streams and their associated biota, as well as indirect and cumulative impacts such as changes in water temperature, downstream chemistry and sediment transportation. This section discusses these direct and indirect impacts in the context of future conditions under the four alternatives.

Stream habitat and functions have been discussed in Chapter III.C.1 and the potential impacts to the streams from MTM/VF have been presented in Chapter III.D. Among the ecological functions of headwater streams are nutrient cycling and the maintenance of unique species and populations which provide a reservoir for genetic diversity in aquatic systems on a national basis. Changes in downstream thermal regimes, flow regimes, chemistry and sedimentation due to MTM/VF are discussed under the stream impairment issue in Chapter II.C. The impacts from MTM/VF, along with other disturbances such as road building, logging, and influx of residents, may result in a cumulative affect on aquatic resources within a watershed. A number of actions are proposed to standardize data collection, collect and analyze water quality and stream data, and develop a BMP manual for stream mitigation.

1. Consequences Common to the No Action Alternative and Alternatives 1, 2, and 3

a. Direct Stream Loss from MTM/VF

This section portrays consequences of past MTM/VF regarding loss of streams projected into the future using two measures: valley fill area and mining permit area. The amount of stream loss may differ with alternative selected, but stream loss will occur under all alternatives. Data on loss of linear miles of stream are available from the Cumulative Impact Study [Appendix I] and from the Fill Inventory [Chapter III.K.2]. The cumulative impact study estimated direct stream impacts based on the *permit boundary footprint* (including fills, mineral removal, roads, and incidental support areas), while the fill inventory estimated direct stream impact based only on *valley fill footprints*. Estimation of direct stream impacts based on the entire permit area footprint may overestimate actual direct impact, since not all of the area within the permit boundary is disturbed. Estimates of direct stream impacts based only on the valley fill footprint may underestimate actual direct impact because direct stream impact can occur in production and support areas.

MTM/VF impacts (including valley fills and other permit features) estimated in the Cumulative Impact Study (based on ten years, 1992-2002 of *permit* footprints) were 1,208 miles (2.05 %) of the 58,998 stream miles in the EIS study area. If that rate continued for another 10 years, a total of 4.10% would be impacted by 2013. [Appendix I] The following is a breakdown of stream impacts by *permit* footprint by state in the past ten years in the EIS study area. Kentucky had direct stream impacts of 730 miles (2.1%) of its EIS study area. Tennessee had direct stream impacts of 20 miles (0.4%) in the Tennessee portion of the study area. There were 151 miles (2.1%) of direct stream impacts in the Virginia portion of the study area. Direct impacts totaled 307 stream miles (2.6%) of the West Virginia portion of the study area.

The Fill Inventory calculated miles of streams under approved valley fill footprints in permits issued for the seventeen year period from 1985 to 2001. The total direct stream impact from *valley fill* footprints for the EIS study area for this period is 724 miles, or 1.2 % of the miles of streams within the study area [Chapter II.K.5 and Table IV.B-1]. If valley fill construction continued at this historical rate documented in the Fill Inventory for the next seventeen years (2003-2020), an additional 724 miles (for a total of 2.4%) could be impacted.

Table IV.B-1
Study Area Stream Miles Under Valley Fill Footprint

Year	KY	TN	VA	WV	Total
1985	26.98	0.22	4.60	21.02	52.82
1986	18.00	1.42	4.04	7.39	30.85
1987	32.07	0.51	2.22	1.66	36.46
1988	34.96	0.33	4.27	7.55	47.11
1989	20.81	0.00	4.32	11.66	36.79
1990	17.85	0.02	4.05	4.66	26.58
1991	26.60	0.65	5.16	10.73	43.14
1992	34.90	0.68	4.31	15.12	55.01
1993	26.30	0.00	4.50	11.31	41.81
1994	24.59	0.00	2.33	12.25	39.17
1995	36.83	0.00	3.46	21.58	61.87
1996	31.94	0.58	4.01	15.91	52.44
1997	28.99	0.43	3.00	15.58	84.00
1998	24.60	0.92	5.36	13.55	44.43
1999	25.19	0.31	4.06	19.90	49.46
2000	15.56	0.24	6.58	22.41	44.79
2001	10.19	0.00	1.09	1.73	13.09
Total	436.36	6.31	67.36	214.01	724.04

[Source: Valley Fill Inventory, Chapter III.K.2., Table K-8]

Studies show that while invertebrates and microbiota in headwater streams are only a minute fraction of living plant and animal biomass, they convert leaf litter to coarse and fine particulate organic matter. Scientific literature, for studies in states outside the EIS region, estimate that about one kilogram of organic matter per meter length of stream transports downstream on an annual basis. This matter is transported downstream and is part of the food supply for invertebrate populations; which, in turn, become food for fish populations. Accordingly, the length of stream buried by mining or valley fills displaces the biomass and proportionate amount of energy provided by fine- and coarse-particle organic material leaving a particular reach of headwater stream. [Chapter III.D.; Appendix I; Appendix D (Value of Headwater Streams Workshop); Wallace, 1992.]

Research outside of the EIS study area found that when leaf litter was excluded from a stream, macro invertebrates dependent on the litter declined, as did invertebrate predators and salamanders. The research also established that rapid recovery of aquatic organisms occurred when leaf litter was restored. Consequently, leaf litter exclusion as a result of MTM/VF may affect aquatic productivity downstream to some extent due to this terrestrial-aquatic interrelationship.

No widely-accepted, standardized testing procedures exist for measuring the presence/absence of the fine and coarse organic matter and consequent energy contributions of stream. Thus, the EIS stream chemistries studies in West Virginia and Kentucky did not document the effect of stream loss on the downstream energy continuum.

The estimates of potential future stream loss are liberal, in that they do not take into account the focus on avoidance, minimization, and mitigation requirements in the 2002 NWP 21. Independent of any other future actions, the 2002 NWP 21 will likely reduce the rate of stream loss that occurred in the preceding ten-year time frame for permit footprints; or in the 17-year time frame for fill footprints.

Similar effects to headwater and larger streams occur from other human activities, such as road building and development for industrial/residential/commercial sites in steep-slope Appalachia. As discussed by Yuill in the post-mining land use report, suitable developable land is in short supply in some parts of the West Virginia study area [Appendix G]. Consequently, creation of areas suited for roads and development often places fill materials in streams. Based on the current demographics in the EIS study region, coal mining operations are likely to have the consequences of disturbing more land than residential, industrial or commercial development in the coalfields. Nonetheless, the CWA requires consideration of the cumulative effects of all activities and SMCRA requires assessment of the hydrologic cumulative effects for all coal mining in a watershed. These evaluations are integral to decision making on authorizing MTM/VF projects and aid in minimizing the cumulative effects of direct stream loss.

The No Action Alternative and action alternatives will not eliminate the loss of stream segments and reduction in organic matter transported downstream. In the absence of standardized testing and research, it is not clear to what extent this direct stream loss indirectly affects downstream aquatic life. It is also not evident to what degree reclamation and mitigation (e.g., drainage control and revegetation) offset this organic nutrient reduction. The direct impacts of stream loss are permanent, but the downstream effect from organic energy loss may be temporary. Existing CWA programs indirectly address these effects through technology-based effluent limits, state water quality standards, TMDLs, and other provisions designed to assure overall watershed health.

SMCRA and CWA program improvements common to the action alternatives, summarized in Chapter II.B and described in Chapter II.C, will serve to reduce future direct stream loss. Implementing requirements, policies, and guidance relative to increased/shared data collection and coordinated analysis of predicted impacts by the agencies; emphasis on avoidance, fill minimization, and site selection; mitigation of the loss of aquatic functions; use of ADIDs and BMPs; and, establishing minimal/cumulative impact thresholds (if feasible) and consistent stream definitions and delineation techniques, will operate to minimize future direct stream loss under all action alternatives.

b. Indirect Stream Impacts

The consequences of direct stream loss and energy transport reductions, discussed above, also indirectly affect downstream stream reaches. MTM/VF has the potential to alter the chemistry, water temperature, flow regime and geomorphological features downstream. Stream chemistry showed increased mineralization and a shift in macroinvertebrate assemblages from pollution-intolerant to pollution-tolerant species. Water temperatures from valley fill sites exhibited lower daily fluctuations and less seasonal variation than water temperatures from reference sites. Daily stream flows from studied valley fill sites exhibited greater base flow than reference sites. Smaller sediment particle sizes were found in downstream substrate. [Chapter III.D; Appendix D]

Scientists postulate that stream thermal regimes, which can influence microbial activity, invertebrate fauna, fish egg development, larval growth, and seasonal life cycles, may be affected by valley fills and sedimentation ponds at the base of the valley fills. Scientists also theorize that, as mining or other human development practices eliminate first order streams, unique biological diversity may be affected, especially if rare species occur in only one or two spring or seepage areas and are impacted. [Chapter III.D; Appendix D]

Headwater stream systems do not have a tremendous capacity to provide purification functions. Although these ecological processes are not one requiring protection, the absence of streams to provide this function reflects the sensitivity of the system to inputs of a variety of potentially toxic materials. As groundwater and infiltration move through surface coal mining operations a variety of potentially toxic materials are released into the environment, including metals and mineral constituents such as sulfates which, if at high enough levels, may act by altering physical characteristics of water (e.g. pH or specific conductance). Headwater streams, with their innately limited buffering capacity and lack of ability to sequester and precipitate out contaminants, tend to be at risk from any input of toxic materials exceeding the streams limited capacity to assimilate. [Chapter III.D.]

The EPA Water Chemistry Report found elevated concentrations of sulfate, total and dissolved solids, conductivity, selenium and several other analytes in stream water at sampling stations below mined/filled sites [Appendix D; USEPA, 2002b]. Other studies found elevated concentrations of sulfates, total and dissolved solids, conductivity, as well as other analytes in surface water downstream from MTM/VF sites.

Studies conducted as part of this EIS show that aquatic communities downstream from MTM/VF differ from unmined headwater streams in several ways. In most cases, there were differences in biological assemblages. Generally, macroinvertebrate communities below mined areas were more pollution tolerant than those below unmined watersheds. However, biological conditions of filled sites represented a gradient of conditions from poor to very good, demonstrating a wide range of conditions that may be found in aquatic communities downstream from MTM/VF or other human disturbances [Appendix D; USEPA, 2000 (Green, et. al.)].

The Aquatic Impacts Statistical Report indicated that ecological characteristics of productivity and habitat are easily disrupted in headwater streams [Appendix D; USEPA, 2003)]. Accepted indices and comparisons correlated chemical and biological (macroinvertebrates and fish) parameters in unmined, filled, filled/residential and mined sites. The analysis indicated that biological integrity

is hampered by mining and that unmined sites have a higher biotic integrity with more taxa and more sensitive taxa. The strongest association with water chemistry suggested that zinc, sodium, and sulfate concentrations were negatively correlated with fish and macroinvertebrate impairments. Selenium and zinc were negatively correlated with the West Virginia Stream Condition Index (WVSCI). The potential drivers of these conditions are mining practices, material handling practices, and the geological factors associated with specific coal seams and overburden. However, the study also concluded that insufficient data existed to determine the temporal nature of the impact or the distance downstream that the impacts persist. Due to the limited scope of the studies performed for the EIS, no correlation could be made of downstream impacts with the age, number, and size of mining disturbances and fills, nor could data differentiate impacts of mining, fills or other human activity in a watershed.

Wetlands are among the most effective ecosystems for removing pollutants and purifying wastes. Wetlands operate through a series of interdependent physical, chemical and biological mechanisms that include sedimentation, adsorption, precipitation and dissolution, filtration, biochemical interactions, volatilization and aerosol formation and infiltration [USEPA, 1999; Appendix D]. Constructing wetlands is a possible mitigation measure for impacts to headwater streams. While this issue is complex, there may be opportunities to construct wetlands at MTM/VF operations, including at the toe of fills where groundwater emerges to improve the water quality of streams downstream from fill areas. The success of these wetland systems to improve water quality would be highly dependent on the toxicity of the water initially.

Other human development activities, such as logging and other types of excavation, also pose potential threats to the nutrient cycling function, sedimentation, and other physical, chemical, and biological impacts to headwater streams in the EIS study area. However, the permanent nature of filling discussed under direct loss, as compared to the more temporary impacts from forestry, would suggest that MTM/VF impacts (e.g., nutrient cycling function, biological diversity, mineralization, substrate composition, etc.) of headwater stream systems may have a longer-term impact on this system, although data do not currently suggest the duration of these impacts.

The indirect impacts from MTM/VF will continue regardless of alternative selected by decision makers. However, CWA programmatic controls discussed in direct stream loss are in effect under all alternatives and share the common objective of assuring the overall health of the watershed [Chapter II.C.3.a.1]. The NWP 21 and IP process require the following:

- use of functional assessment stream protocols to identify the type and character of aquatic resources that may be impacted
- prediction of potential impacts and alternatives analysis
- avoidance of high quality resources, if practicable to site activities elsewhere
- minimization of impacts
- adequate mitigation to offset unavoidable impacts, function for function
- demonstration that impacts, individually and cumulatively, are minimal for NWPs and less than significant degradation for IPs
- meeting water quality requirements

The actions proposed and common to Alternatives 1, 2, and 3, when implemented, will further mitigate indirect impacts. In particular, the coordinated and collaborative MTM/VF proposal review

described in the alternatives should result in improved environmental outcomes because of the synergy of joint reviews and shared expertise, on top of improved and increased data collection and analysis. Consideration of the necessity of additional water quality parameters by EPA will take into account the indications of increased mineralization and biological effects from MTM/VF, along with additional study of the duration and downstream extent of these impacts relative to size, number, and age of MTM/VF impacts. The development of a BMP manual for mitigation, in concert with a similar document for improved forestry reclamation, would suggest practices designed to reduce the indirect effects in association with the existing CWA controls described above.

c. Stream Hydrology

Hydrologic modeling studies performed for the MTM/VF EIS found that peak storm water flows are slightly higher during and after mining. The West Virginia Governor's study on flooding found similar peak runoff increases due to timbering. The studies concluded that whether or not these increases exceed bank-full conditions and contribute to flooding are highly site dependent. Hydrologic results from field studies indicate that runoff and ground water are stored in valley fills, tending to increase the base flow of the stream and decrease the peak flows during storm events. As discussed in indirect impacts above, since valley fills create more perennial base flows, the water temperature is less variable than in unfilled watersheds. [Chapter III.G.; Appendix H]

These types of flow impacts appear to be unique to MTM/VF and timbering activity in the study area. Other activities that might affect hydrologic patterns, such as agricultural practices or water withdrawals, appear to have limited impact. MTM/VF, forestry, and human modifications to stream channels and flood plains (fills, bridges, stream crossings, and other encroachments) are the dominant impacts altering the hydrologic patterns in the study area. Alterations in hydrologic patterns may have further impacts on other ecological processes and are discussed under those processes.

CWA Section 404 reviews of MTM/VF activities consider flooding potential. SMCRA considers not only the flooding potential of individual projects, but also the cumulative impacts to the hydrologic balance (including the impacts to quantity and quality of surface water) of all surface coal mining and reclamation operations in a defined cumulative impact area. In addition to the existing flooding and cumulative impact requirements in effect under all alternatives, the action alternatives consider clarifying the appropriate analytical methods and potential remedial techniques to assess and counter flooding risk.

d. Fill Minimization

Fills sizes and numbers, over time, were previously discussed in relation to direct stream loss and are provided in Chapter III.K.2. Prior to 1999, the design of excess spoil disposal areas focused on ensuring that excess spoil fills were safely designed and stable as opposed to avoiding streams and minimizing the volume and areal extent of excess spoil fills. As discussed later under the heading of fill stability, this focus appears to have been effective in reducing the number of slope movements. Increased emphasis on SMCRA proposals attaining AOC since 1999 has resulted in smaller fills. Concurrently, increased accentuation on avoidance, mitigation, and mitigation in the CWA Section 404 program has reduced fill sizes. These regulatory provisions, along with the general 250-acre minimal impact threshold applied by the COE in West Virginia, shifts in coal

production, court injunctions, and difficulty in finding investment capital may have also resulted in fewer and smaller fill impacts. [Chapter II.D.]

The No Action Alternative would continue to emphasize AOC, minimizing the amount of spoil identified as excess, and, as a result, minimize valley fill volume and associated impacts. The SMCRA agencies in the EIS study area (OSM in Tennessee, DSMRE in Kentucky, DMLR in Virginia, and DEP in West Virginia) have developed technical guidelines that assist the surface mining permit applicant to demonstrate that excess spoil will be minimized by returning the maximum amount of mine spoil to the mined-out area. Policies established by the four SMCRA agencies for determining AOC and thus accounting for the excess spoil can be found in Appendix J. The West Virginia "AOC+ protocol" is a systematic method for maximizing the return of spoil to the mined out area. Chapter IV.I.4.a describes how this fill minimization analysis can result in fewer and smaller fills and commensurate reductions in stream impacts and mitigation costs.

The AOC+ and other guidelines do not, in of themselves, consider the condition of the streams considered for fill location; however integral aquatic ecosystem evaluations as part of the SMCRA review can result in narrowing the potential valleys evaluated for fills, based on a preference for disturbing previously-impacted or impaired streams segments over those in a natural, undisturbed condition. Such quantified, objective evaluations of excess spoil disposal plans result in reduced impacts to valleys and streams by requiring that applicants demonstrate that fill minimization has been achieved in their proposed mine plans.

Another consequence of fill minimization may be valley fill or backfill stability. The strong financial incentive to avoid streams will result in higher and, possibly, steeper backfills. Minimizing stream length impacted will also force valley fills higher in watersheds, where steeper foundation conditions are typical. Steeper and higher backfills and valley fill toes on steeper foundations present higher probabilities for slope instability. These conditions increase the challenge to geotechnical engineers to design fills and backfills to meet the SMCRA safety factor requirements. The SMCRA regulations do not allow construction of valley fills under steep foundation conditions without special measures to assure stability. Design and construction costs for more stable valley fills can be considerable if rock toe buttresses or key-way cuts are necessary to shore up the out slopes.

Under the No Action and action alternatives, the CWA Section 404 program requires demonstrations of avoidance, minimization, and mitigation of unavoidable impacts. The consequences of these provisions were discussed in the direct stream loss and indirect impact narrative above, and may not have markedly different consequences relative to project-by-project fill minimization. However, Actions 3 and 9 combine to clarify the OSM SBZ rule and develop rules requiring applicants to demonstrate excess spoil is minimized, streams have been avoided as practicable, and that fill locations represent the least environmental damaging alternative. By increasing SMCRA program consistency with CWA Section 404 objectives, fill minimization would become a common goal assessed with uniform importance across the programs. These proposed SMCRA changes, in aggregate with the coordinated decision making envisioned under the three action alternatives and other proposed actions, would provide incremental benefits over no action.

For instance, additional resource data and improved impact predictions would result in more-informed decisions about fill numbers, location, and sizes. Similarly, increased consideration of

mitigation requirements and better controls on mitigation success should improve environmental consequences over the No Action Alternative. The effect of alternative analysis and mitigation costs on reducing fill numbers and sizes is discussed in the Chapter IV.B.1.e and IV.I. EPA and COE exploration of designating certain streams as generally unsuitable for fills could reduce cumulative effects of valley filling [ADID, Chapter II.C.3, Action 4]. The information sharing and automation of data relative to aquatic resources should also have a positive effect on minimizing fills, individually and cumulatively.

The continued analysis of data collected during implementation of the CWA Section 404 program by the COE and possible future identification of minimal and cumulative impact thresholds has the potential to minimize fill sizes. Mining companies have demonstrated that these thresholds, which define the appropriate CWA Section 404 permit process, influence mining plans. During the interim permitting process in WV (as a result of the *Bragg* settlement), applicants for 81 MTM/VF projects limited fills to less than 250-acre watersheds. Only 5 applicants proposed MTM/VF projects with fills exceeding this watershed size. This threshold would continue to apply to certain geographic locations under the No Action and Preferred (Alternative 2) Alternatives and it is anticipated that the consequences to fill size would continue.

Although a minimal impact threshold may reduce the size of fills, it could actually cause greater stream impacts by requiring the construction of valley fills in a greater number of headwater stream segments. However, cumulative impact requirements of the CWA Section 404 and SMCRA are designed to evaluate the benefit of fewer larger fills versus greater numbers of smaller fills. This consideration should occur under all alternatives; although the action alternatives, with the greater coordination and increased data collection and analysis, should create improved results over the No Action condition.

e. Mitigation

The effectiveness of reclamation and mitigation practices to restore stream habitat and aquatic functions impacted by MTM/VF are discussed in Chapter III.D and Appendix D. The alternatives proposed, including the No Action Alternative, assume successful mitigation through on-site reclamation and on-site and off-site mitigation. These practices may include stream construction or enhancement, the construction of other aquatic systems, such as wetlands, and the restoration or enhancement of riparian habitat to compensate for the loss of aquatic functions. Preservation of high quality streams through creation of conservation easements or land trusts, and the payment of in lieu mitigation fees for stream protection and restoration measure would be included as compensatory mitigation possibilities. Mitigation requirements are described in Chapter II.C.6 and project examples are discussed in Chapter III.D.

Because all alternatives require mitigation of unavoidable impacts to the waters of the U.S., applicants will be seeking sites suited for restoration. Limitations exist for developing in-kind mitigation projects on reclaimed mine sites. In-kind mitigation must restore or create headwater stream habitat on the reclaimed mine area to replicate the functions lost from direct stream loss. The consequences of the No Action Alternative are dependent on the ability of the COE and SMCRA agencies to require the applicant to achieve functional replacement through on-site reclamation. Additionally, the COE must also require the applicant to make up any mitigation deficit through off-site, in kind or compensatory mitigation projects.

The Appalachian coalfields provide almost limitless opportunities for watershed improvement, following more than 100 years of abandoned mine land (AML) problems. Mine drainage pollution, eroding spoil on the downslope, clogged stream channels, abandoned highwalls and coal refuse areas, and other orphan land problems exceed the capacity of the SMCRA AML Trust Fund. Many of the problems are such low priority it is unlikely that the AML program will ever address them. Mitigation projects for watershed restoration of AML problems, oil and gas industry problems, and a host of other watershed management issues (encroachment, sewage treatment, dredging, creation of wetlands, re-channelization using state-of-the art stream restoration, etc.) could not only offset but also enhance aquatic resources. Some mitigation projects may be possible in the same watershed as the MTM/VF project and may provide a close fit to the functions lost by valley fills (in-kind, in-basin). Other mitigation projects may be in the same basin or elsewhere and not provide the exact match of functions lost by valley fills, although related aquatic resource improvements would occur (out-of-kind or in lieu fee).

The renewed NWP 21 has been in effect a little over one year. Due to the recent *Rivenburgh* injunction, the effectiveness of mitigation to offset unavoidable impacts from MTM/VF projects has not been widely demonstrated. If future mitigation mirrors past intentional or unintentional reclamation practices and state-required mitigation projects, successful restoration of habitat for organisms requiring lotic (flowing) conditions may be very limited. Selection of the No Action Alternative could also result in out-of-kind mitigation projects successfully developed on MTM/VF reclamation sites that generally result in the creation of palustrine or pond-like wetland or linear, drainage ditch-type wetlands. These water bodies provide some of the same functions as headwater streams, but they do not fully compensate for the physical loss of aquatic habitat or serve all of the functions affected by MTM/VF activities, especially if impacted streams were of high quality. Stream relocation, aquatic habitat restoration, and natural channel configurations are also utilized in reclamation. Sediment stabilization, wildlife support, and potential water quality improvements are other types of aquatic resource mitigation projects that were most successful in the past and could be employed under the No Action Alternative. The No Action Alternative provides, under NWP 21 and SMCRA, that on- or off-site mitigation plans must be successfully completed. Inspection and financial assurance of mitigation activities are required under the No Action Alternative; but mitigation procedures or the agencies are not as coordinated as proposed under the action alternatives.

In most situations, under all alternatives, some type of on-site restoration, as a component of reclamation, would be included as part or all of the mitigation needed to replace lost functions from headwater streams. Where the streams directly impacted from mining are of low quality, restoration of stream functions on-site may be the only required mitigation. However, for most sites it is anticipated that both on-site and off-site mitigation will be necessary to insure that only minimal individual and cumulative impacts occur. Under all alternatives, the utilization of a stream assessment protocol provides a more accurate characterization of the loss of aquatic functions and the ability to more accurately predict the opportunity to restore aquatic functions loss at the reclamation or mitigation site. The protocol, described in Chapter II.C.6.a.1, also plays a substantial role in identifying high quality streams for avoidance, to reduce the impacts to these aquatic resources as well as the associated mitigation costs.

The functional assessment will apply under all alternatives, and involves the application of the developed models and the calculation of ecological integrity indices for a defined headwater stream

ecosystem under existing (i.e., pre-project) conditions and predicted (post-project) conditions. The results of using the protocol are the following:

- Description of the potential impacts of a proposed project
- Description of the actual impacts of a completed project
- Identification of ways to avoid and minimize impacts of a proposed project
- Determination of the least damaging alternative for a proposed project
- Determination of compensatory mitigation needs for a proposed project
- Determination of restoration potential for headwater streams
- Development of design criteria for stream restoration projects
- Planning, monitoring, and managing stream mitigation or restoration projects
- Evaluation of performance standards or success criteria for headwater stream mitigation efforts
- Comparison of stream management alternatives or results
- Determination of appropriate in-lieu-fee ratios
- Identification of priority sites for in-lieu-fee mitigation projects.

An example of protocol application is provided in Chapter IV.I.4.c. In the case study, an eastern Kentucky coal company proposal to construct three valley fills in 1,562 linear feet of intermittent stream reaches and 3,132 linear feet of ephemeral stream reaches; the largest headwater stream reach drained 246 acres. Three temporary sediment ponds were proposed to impact 300 linear feet of ephemeral stream and 2,200 feet of intermittent streams. Approximately 950 linear feet of ephemeral stream and 1,844 linear feet of intermittent stream reaches were proposed for temporary sediment transport impacts between the fill areas and the sediment ponds.

After utilizing the stream assessment protocol to evaluate the stream impacts and the amount of mitigation necessary, the company presented a revised application and a new proposal. The use of the protocol provided a mechanism for identification of higher quality streams impacted by the original proposal and allowed consideration of costs of different alternatives for the mining plan. The company determined that they could dispose of more material in mined areas and reduce the amount of excess spoil proposed for valley fills. The company proposed to avoid placing fill material into waters of the U.S. except for one fill and one sediment pond. The valley fill was sited in the lowest quality stream (impacting 980 linear feet of intermittent stream), further reducing mitigation requirements. The applicant satisfied compensatory mitigation needs through a combination of on-site stream restoration of the areas between the fill and ponds (and beneath the ponds, upon removal), incorporating natural channel design into their new stream channel construction and payment of in-lieu-fees to make up the balance for the permanent losses associated with the one valley fill. By using the stream assessment protocol and choosing to avoid and minimize stream impacts, the required in-lieu mitigation fee was also reduced from approximately $300,000 to $128,000.

As a consequence of all alternatives involving mitigation, there will be a strong disincentive for the applicant to disturb stream segments. The cost of mitigating to restore aquatic functions is proportionate to the quality of stream segments impacted. That is, the consequences of mitigating high quality streams will be greater than impaired streams. Based solely on the COE example, the costs of mitigating (by in-lieu fee agreement) 724 miles of valley fill stream impacts in the Fill Inventory would exceed 516 million dollars.

The No Action Alternative and the three action alternatives could also provide additional environmental benefit through the mitigation requirement. If mitigation proves infeasible in certain locations, no mining could occur. If fill minimization/mitigation is difficult or impossible because of the application of the CWA 404(b)(1) Guidelines, some coal reserves may not be minable. The absence of mining in any area would result cumulatively and individually in less impacts to streams.

f. Stream Segment Definitions

As indicated in Chapter II.C.2, the Federal and/or state agencies propose to develop guidance, policies, or institute rule-making for consistent definitions of stream characteristics and field methods for delineating those characteristics. This action is common to all action alternatives.

Development of consistent definition in regulations and guidance for field delineation would provide another incremental benefit over the No Action Alternative. This benefit would occur because delineation of stream characteristics is key to understanding the aquatic resources proposed to be impacted and the level of mitigation required to offset unavoidable impacts. Consistent understanding of terms of regulatory significance improves communication among the regulated industry, the agencies, stakeholders, and provides the basis for both environmental, regulatory, and business decisions. Absent this action, confusion will continue in the No Action Alternative. The potential exists that misunderstandings on delineation could result in impacts to stream segments that might not occur with the additional information and understanding.

g. Bonding and Inspection

There are no defined, established procedures between COE and SMCRA authorities for coordinating on-site and off-site mitigation requirements, such as bonding and inspection. As such, there are both inefficiencies and risk in the current system. The risk is that in maintaining separate, uncoordinated systems, some aspects of a mitigation project may not be completed as required. The inefficiencies are present, as the current system now requires separate permitting, separate monitoring/inspection, and separate bonds for what is essentially a single (or at least closely-related) mining and mitigation project (reclamation/mitigation). Implementation of Action 10 would coordinate SMCRA and CWA requirements to establish financial liability (e.g., bonding sureties) to ensure that reclamation and compensatory mitigation projects are completed successfully.

2. Consequences Common to Alternatives 1, 2 and 3

Alternatives 1, 2, and 3 share actions designed to be more protective of aquatic and other resources, summarized in Chapter II.B and fully described in Chapter II.C, that would cause the following regulatory program changes, policies, or guidance:

- Consistent definitions of stream characteristics and field methods for delineation;
- Clarification of OSM stream buffer zone rule and development of excess spoil requirements for alternatives analysis, avoidance, and minimization;
- Continued evaluation of MTM/VF effects on water quality and EPA recommendations for new standards, as appropriate;
- Refined science-based protocols for assessing aquatic function, making permit decisions, and setting mitigation requirements;

- BMPs for the following:
  - functional assessment and mitigation
  - flooding analysis and remediation
  - reclamation with trees
  - control of fugitive dust and blasting fumes;
- Coordinated permitting, data collection and sharing, mitigation bonding and inspection;
- Development of science-based minimal impact thresholds for individual and cumulative impacts, if feasible; and,
- Program changes, if necessary to enhance ESA compliance

The action alternatives, by virtue of formalized coordination of agency roles, facilitate results that would be delayed or would not occur under the No Action Alternative:

- Enhanced environmental protection and minimized impacts through better information, analysis and collaborative government regulation.
- Improved government efficiency; implementing programs to achieve coordinated data collection/sharing and application processing that fulfill these objectives:
  - assure adherence to performance standards;
  - eliminate duplication by the agencies and applicants; and
  - provide for better integrated public participation.
- Supplemented data collection to accomplish the following:
  - better characterize environmental resources and establish their function in the ecosystem;
  - monitor impacts based on changes from baseline condition to determine if predictions were accurate; and
  - demonstrate compliance and/or reclamation/mitigation success.
- Strengthened prediction of impacts based on better data and analysis.
- Articulated regulatory concepts in the regulation of surface mining operations that accomplish these goals:
  - provide clear understanding of requirements and set expectations of industry and stakeholders
  - for making decisions;
  - improve environmental protection; and
  - assure public safety.
- Expanded best management practices in planning/design of mining, reclamation, and mitigation practices.

The action alternatives considered were developed to result in a better informed public and provide more meaningful participation, in part because plans would more thoroughly address impacts to environmental resources. Applicants would benefit from integrated regulatory programs under state and Federal environmental statutes. Many actions facilitate streamlined, sequenced review processes while improving environmental protection. Common data elements in a joint application form could lead to more efficient analytical approaches among the agencies. Reliance on these analytical results could facilitate agreements among agencies and provide a basis for one agency to confidently rely on the findings of another agency. A coordinated review process should reduce processing times and costs of permit applications, which may offset some of the increased costs and

times associated with the additional data collection and analysis requirements of the actions. The program costs of Federally- versus state-administered application reviews, inspection, and enforcement for these actions are described in Chapter IV.I.

The aquatic resource data mandated by different regulatory programs results in costly collection and analysis of voluminous information, typically only assessed for particular program requirements. Compiling similar data from varied sources could serve multiple program goals and objectives. The use of GIS to compile other relevant resource, ecosystem, or community information is a logical augmentation to the aquatic data for use in COE NEPA compliance. Use of information technology to collect, compile, screen, and update aquatic and other resource information in GIS, linked to various databases, would provide for better informed and timely permit decisions regarding aquatic impacts and a reference library to assist in future decisions.

Increased environmental benefits to aquatic and related resources would be realized from the use of a coordinated permit process in combination with other regulatory aids and tools such as ADIDs and the COE stream assessment protocol. For example, the collaboration that would occur among the agencies in this coordinated regulatory process under the action alternatives would facilitate the effective application of the alternatives test required by the CWA Section 404(b)(1) Guidelines. The institutional expertise unique to each agency could be employed in consideration of a greater range of alternatives, such as placing excess spoil in adjacent, previously-mined areas in order to avoid or substantially minimize fills in waters of the U.S.

Moreover, joint evaluations of MTM/VF proposals would result in more expansive considerations of both environmental impacts and effective treatments to mitigate those impacts. This coordinated process would also facilitate selection, implementation and monitoring of mitigation projects. The coordinated process and actions that make up the action alternatives could minimize adverse environmental effects by enhancing consideration of the least damaging practicable alternative in fill placement; minimization of excess spoil material; consideration of adverse cumulative environmental effects; and, technology transfer to identify the best practices reclamation techniques available to avoid or minimize adverse environmental impacts.

Better stream protection from direct and indirect effects would result from improved characterization of aquatic resources; operations designed to avoid and minimize adverse effects and restore aquatic functions; and compensatory mitigation plans with improved design, inspection, and enforcement. Excess spoil fills would become smaller and placed in locations that minimize adverse environmental effects.

Under all action alternatives, the consequences would include development of a Memorandum of Understanding (MOA), outlining coordinated data collection/sharing, the process for permit review sequencing, agency responsibilities, and other relevant matters. Common to all alternatives is also development of a Field Operating Procedure (FOP) document to elaborate on the specifics of the coordinated, collaborative review and regulatory processes of the agencies.

The development of an MOA and FOP would promote a coordinated permit process; regular pre-application and Joint Permit Processing (JPP) meetings, as appropriate; standardized data collection to address identified gaps; further refinement and implementation of the COE stream assessment protocol in evaluating permit applications; development of permit application assessment and

mitigation procedures based on these data; and utilization of and networking the expertise of the various agencies. The MOA could also reinforce protection of special environmental areas by containing information on existing regulatory tools for environmental protection of high value aquatic or other resources (e.g., underscoring the ADID process, designated special aquatic sites, and "Aquatic Resources of National Importance," as well as lands designated unsuitable for mining under SMCRA. An MOA could identify the role of the CWA Section 404(c) and (q) elevation process in the coordinated approach and describe the type of site-specific information necessary to justify formal written requests to the COE requesting NWP applications be processed as IP. The MOA or FOP could encourage interagency site visits to gather site-specific resource information on which to base impact predictions, allowing the agencies to make more informed decisions. The consequence is a coordinated, consistent impact prediction.

FOPs could establish particulars for efficient application sequencing and facilitate coordinated processing by a lead agency. A consequence of all of the action alternatives may be development of decision-making and dispute resolution procedures.

3. Consequences Unique to Alternative 1

Under this alternative, all MTM/VF projects proposing valley fills in waters of the U.S. would initially be reviewed by the COE as a CWA Section 404 IP rather than as a general permit [Chapter II.C.1.b.; Action 1.1]. The COE would make an initial case-by-case determination of the size, number, and location of valley fills in waters of the U.S. Following this initial determination by the COE, the applicant could commence the SMCRA and other requisite application processes (e.g., NPDES, MSHA, etc.). The result of this alternative would be a series of consecutive, coordinated reviews and decisions by the COE and appropriate SMCRA agency. Any subsequent actions under SMCRA or other laws on a permit application would recognize the constraints established by the COE. The COE would also rely on the subsequent SMCRA permit application for information pertinent to whether an EIS or EA is needed.

The consequences of processing most MTM/VF applications as IPs are the case-by-case application of the CWA Section 404(b)(1) Guidelines, the NEPA, and public interest review. These processes present the potential for a more lengthy permit process for the applicant and additional data collection and analysis. For instance, NEPA compliance may require either development of an EA/FONSI or EIS. NEPA focuses not only on the environmental effects of the proposal, but all human activities in the area. NEPA and IPs imposes greater scrutiny of the application by a wider audience of government agencies and the public.

Conversely, processing MTM/VF applications as IPs provides the applicant the possibility of receiving authorization for larger fills. While CWA Section 404 requires mitigation of all unavoidable impacts, an IP project must mitigate to a level less than significant adverse impacts. Projects processed under a general (e.g., NWP) permit must mitigate to minimal impacts. Accordingly, these impact levels could correspond with approval of larger fills under an IP.

Alternative 1 involves the COE performing the necessary avoidance, fill minimization, and mitigation assessment of MTM/VF proposals. The COE and EPA have affirmed that use of the WVDEP AOC+ policy satisfies the requisite alternative analysis required by the CWA 404 (b)(1) Guidelines. For consistent application across the various COE Districts with jurisdiction over CWA

Section 404 coal mining activities in Appalachia, the COE would either evaluate the adequacy of existing state SMCRA authorities AOC policies or develop other procedures for applicants in Virginia, Kentucky and Tennessee to demonstrate that projects have satisfied the CWA Section 404 (b)(1) Guidelines.

Inasmuch as the COE is initially determining the size, number and location of fills under Alternative 1, it would not include SMCRA agencies requiring or applying functional assessment protocols [Chapter II.C.6; Action 11]. The consequence of Alternative 1 not containing this requirement in the SMCRA program is insignificant since the COE would apply the protocol.

Alternative 1 also does not include a continuation of any regional conditions established as part of the No Action Alternative. This action would be unnecessary since the applications would all begin processing as an IP.

Alternative 1 includes the potential use of the advance identification (ADID) process by the EPA and COE to designate specific headwater resource locations as generally unsuitable as fill [Chapter II.C.3; Action 4.1].

4. Consequences Unique to Alternative 2

The consequences of Alternative 2 relevant to aquatic (and other environmental) resources would include those described in Chapter IV.B.2. and IV.B.3. The major distinction of Alternative 2 is the process and coordination among the COE, EPA, OSM, FWS, and their state counterparts in considering MTM/VF proposals. Another distinction of Alternative 2 is the concept of a joint application. Such an application would assure the most thorough description of the resources affected, projected impacts to those resources, and a detailed reclamation/mitigation plan.

The COE would make case-by-case evaluations of site-specific impacts to determine the appropriate CWA Section 404 review process (i.e., IP or NWP 21). Any existing regional conditions, such as a 250-acre watershed minimal impact threshold, would continue to be implemented under this alternative until revoked or replaced. These regional conditions are described in the No Action Alternative [Chapter II.C.1.a.1.].

Following the COE determination of the appropriate CWA Section 404 process applicable to the MTM/VF application, the consequences would be identical to Alternative 1 for any proposals determined to warrant an IP. Conversely, those applications determined to merit NWP 21 authorization would begin processing with the SMCRA regulatory authority, as described in Alternative 3. Following SMCRA processing, the COE would consider NWP 21 authorization, based largely on the SMCRA review.

These evaluations would be based on proposal-specific information sharing and early coordination of these agencies. Facilitated sequencing of agency permitting processes would have the consequence of better-informed and timely decision making. This alternative is the preferred alternative for the agencies because of the improved efficiency, collaboration, division of labor, benefits to the public and applicants, and the recognition that some proposals will likely be suited for IPs, and others best processed as NWP 21.

Independently, but in concert with these actions under Alternative 2, the current rule-making effort by OSM would continue, in order to clarify the SMCRA obligations to minimize excess spoil and the adverse impacts stemming from valley fill construction [Chapter II.C.5.a.2]. This revision to the SMCRA regulations would not only be in accord with SMCRA provisions, it would also increase consistency with CWA Section 404(b)(1) Guidelines. As a consequence of Alternative 2 OSM would also consider whether additional future rulemaking is warranted to increase consistency with the CWA Section 404 program and/or fine tune fill minimization and alternative analysis that grow out of the ongoing rule making [Chapter II.C.3.a.2]. OSM rule-making may be appropriate after experience is gained with Federal and state agencies involved in the development of elements of coordinated decision making and collaborative CWA/SMCRA permitting program.

The creation of the MOA, FOP, joint application, etc., may indicate that additional data collection, impact predictions, and analysis could increase SMCRA consistency with CWA standards, e.g., by satisfying other elements of CWA Section 404(b)(1) Guidelines analysis. OSM could consider future amendments to the excess spoil rules and/or other permitting/performance requirements in this regard. Following state modification of their SMCRA-based programs to conform with OSM rule making, a state might consider seeking CWA Section 404 authority for approval of MTM/VF proposals eligible for the NWP 21, using the COE state programmatic general permit (SPGP) [Chapter I.C.1.a.2]

5. Consequences Unique to Alternative 3

The goal of this alternative would be to enhance the SMCRA programs, as described in Alternative 2 above, to satisfy the informational and review requirements of the CWA Section 404 program. In this manner, the SMCRA process would minimize, to the maximum extent possible, the adverse effects of MTM/VF and create a more effective and efficient permit application review process. The principal difference between this alternative and Alternative 1 is that the enhanced SMCRA regulatory process could provide the regulatory platform to ensure that MTM/VF in waters of the U.S. comply, to the extent allowed by SMCRA through the proposed rule-making, with the CWA Section 404 program. This alternative differs from Alternative 2, which describes a coordinated interagency screening process to determine the type of COE CWA Section 404 permit needed for MTM/VF in waters of the U.S. That is, under Alternative 3, all applications would begin processing by the SMCRA regulatory authority to determine the size, number and location of valley fills.

Alternative 3 is based on an assumption by the COE that MTM/VF applications begin processing as NWP 21 because the SMCRA review is the functional equivalent of an IP. An exception to this assumption is the COE authority to require additional off-site mitigation to offset unavoidable impacts to waters of the U.S., which would be assured by the COE under CWA Section 404 review. Under this alternative, the SMCRA regulatory authority would be the lead review agency, reducing duplication of CWA regulatory control exercised by the COE. This would meet the purpose of the general permit process envisioned by the CWA Section 404(e). [Chapter II.C.1.d, Action 1.3.] While the COE retains responsibility for authorizing CWA Section 404 permits, the information collected and analyzed by the SMCRA agency would allow the COE to process most permits under NWP 21. Under Alternative 3, it is more likely that a state may seek partial CWA Section 404 authority through a SPGP, or through full assumption of the CWA Section 404 program [Chapter II.C.1.a.2].

The COE would also be responsible for mandating and retaining its jurisdiction for appropriate compensatory mitigation to offset unavoidable impacts to aquatic resources. Currently, unlike the COE, SMCRA agencies may not have the statutory basis to require off-site compensatory mitigation. Most states in the EIS study area require compensatory mitigation through either the CWA Section 401 water certification process or state water quality laws. Under this alternative, the SMCRA agency would work closely with the COE to determine the extent of on- or off-site compensatory mitigation needed to offset unavoidable adverse effects of MTM/VF to waters of the U.S. Any regional conditions established under the No Action Alternative will not be continued under Alternative 3.

C. SOILS & VEGETATION

Chapters III.B. and III.F, of this EIS describe the existing Appalachian forest environment (vegetation and soils) and the importance of this forest environment in helping to define the ecosystem as it exists today. As indicted in Chapter III.F., the vast majority (approximately 92%) of the study area is forest land. Mixed mesophytic hardwoods, predominantly comprised of various oaks, maples, yellow poplar, beech, white basswood, and other species, are the dominant forest cover type within the study area.

This EIS contemplates two actions specifically related to deforestation. These actions are identified and described in Chapter II.C.8.b. as Action 13 and Action 14. Action 13 includes the cooperative development and identification of state-of-the-science BMP's for enhancing establishment of forests as a post-mining land use. Action 14 states that if legislative authority were established on either a Federal or state level, reclamation with trees could be required as a post-mining land use. The benefits these actions would provide to the successful establishment of forests on reclaimed mine sites are described in the Chapter II.C.8.b discussion of the actions. These two actions are incorporated in Alternatives 1, 2, and 3.

MTM/VF operations generally impact large areas of the forest community as the development of an individual mine can result in disturbance or removal of a few hundred to a few thousand acres of forest cover. The quality of the forest and the associated habitat impacted by a mine can vary depending on a number of factors such as extent of previous mining, past logging activities, other mineral extraction activities such as oil and gas, previous land management practices, etc. Regardless of the type or quality of forest cover that existed prior to mining, certain impacts can be generalized in association with any mine or any activity that disturbs large areas of forest. For example, unlike traditional logging activities associated with management of a hardwood forest, when mining occurs, the tree, stump, root, and growth medium supporting the forest are disrupted and removed in their entirety.

The likelihood of natural regeneration within the mine site is contingent upon the reclamation practice and post-mining land use chosen. Given that MTM/VF occurs along the ridge tops, reclaimed mines, when the post-mining land use is a category other than forest, typically create large expanses of open area devoid of seed source trees. Seed source trees in adjacent unmined areas are typically at an elevation below the reclaimed ridge top, limiting natural succession of forest cover from adjacent areas [Appendix E (Handel, 2002)]. In this type of ridge line mining and reclamation environment, for a number of years to come, the forest is replaced by a grassland and/or herbaceous/shrub vegetative community with different topographic and hydrologic conditions than those that existed prior to mining.

The Landscape Scale Cumulative Impact Study modeled terrestrial impacts based on past surface mine permit data [Appendix I; EPA, 2002]. Tables IV.C-1 through IV.C-4 were developed from these data and provide a retrospective of the impacts to forest that occurred over the 10-year period from 1992 to 2002. The tables estimate impact to the forest environment (vegetation and soils) in the study area from surface mining during this period at 380,547 acres or 3.4 % of the forest area that existed in 1992. When adding past, present and future terrestrial disturbance, the study area estimated forest impact is 1,408,372 acres which equates to 11.5% of the study area. This number is derived by adding grassland as an indicator of past mining, barren land classification, forest lost

from the last ten years of surface mine permits and a projection of future forest loss that equates to the last ten years. The tables represent a worst case projection or overestimate of impacts to forest cover in the EIS study area because: 1) the data are projected under the assumption that the entire area within the permit boundary would be disturbed, and 2) the data do not include areas where forest regeneration is occurring on some mine sites, i.e., the amount of natural succession or managed forestry would decrease the affected acreage. Forests constantly change and evolve as a result of tree growth, aging, disease, and human disturbances continually affecting the extent and composition of the forest. For example, as one area is disturbed by mining or logging activity (i.e., forest cover removed), other areas which were affected years ago by similar activities such as logging or agricultural development revert back to forest.

The concept of forest regeneration is reinforced by information available on the National Geographic web site at http://magma.nationalgeographic.com/ngm/0211/resources_who.html. The link for the U.S. Forest Services's Forest Inventory and Analysis (FIA,"Forest Census"), provides data on the nation's forest census. This data, based on forest censuses in West Virginia (1989), Virginia (1992) and Tennessee (1999), shows the average annual cubic feet (c.f.) of forest growth (net growing stock) exceeds the c.f. of forest loss (removal and mortality) by 10 million c.f. in Virginia, 241 million c.f. in Tennessee and 257 million c.f. in West Virginia. This type of data for Kentucky was unavailable on this web site. Thus forest "losses" are generally offset by forest "gains" realized by the natural order of succession in the Appalachian region to a forested community. As indicated by these data, forests are dynamic. Neither the census, nor the "worst case" analysis of forest loss, can entirely characterize the "net" impact to forest as a result of a specific activity such as mining. With that in mind, the data in the tables is presented here simply to give the reader a "reasonable" estimate of the extent of forest that may have been affected by mining over the past ten years. The acreage of grassland and transitional areas represent an estimate of past impacts from mountaintop mining.

Table IV.C-1
Estimated Terrestrial Impacts: Kentucky Portion of the Study Area

	Baseline Condition (NLCDS)	Condition from Issued Permits	Projected Future Condition*
Forest Cover (ac)	6,400,838	6,145,256	5,889,674
Forest Cover (%)	92.8	89.3	85.6
Forest Loss (ac)	—	255,582	511,164
Grassland as indicator of past mining impact (ac)	268,603	267,414	—
Quarry/strip mines/gravel pits (ac)	37,710	271,972	—

NLCDS = National Land Cover Data Set
Source: Landscape Scale Cumulative Impact Study of Future Mountaintop Mining Operations, prepared by EPA, 2002.
* Projections are based on the assumption that, if no reforestation of mine sites ever occurred, forest loss acreage similar to the ten years (1992-2002) of permits would occur over the future ten years.

Table IV.C-2
Estimated Terrestrial Impacts: Tennessee Portion of the Study Area

	Baseline Condition (NLCDS)	Condition from Issued Permits	Projected Future Condition*
Forest Cover (ac)	960,455	951,301	942,147
Forest Cover (%)	89.5	88.6	87.8
Forest Loss (ac)	—	9,154	18,308
Grassland as indicator of past mining impact (ac)	59,173	58,980	—
Quarry/strip mines/gravel pits (ac)	1,208	10,601	—

NLCDS = National Land Cover Data Set
Source: Landscape Scale Cumulative Impact Study of Future Mountaintop Mining Operations, prepared by EPA 2002.
* Projections are based on the assumption that, if no reforestation of mine sites ever occurred, forest loss acreage similar to the ten years (1992-2002) of permits would occur over the future ten years.

Table IV.C-3
Estimated Terrestrial Impacts: Virginia Portion of the Study Area

	Baseline Condition (NLCDS)	Condition from Issued Permits	Projected Future Condition*
Forest Cover (ac)	1,166,652	1,137,428	1,108,204
Forest Cover (%)	86.5	84.3	82.1
Forest Loss (ac)	—	29,224	58,448
Grassland as indicator of past mining impact (ac)	129,110	128,120	—
Quarry/strip mines/gravel pits (ac)	18,982	49,458	—

NLCDS = National Land Cover Data Set
Source: Landscape Scale Cumulative Impact Study of Future Mountaintop Mining Operations, prepared by EPA, 2002
* Projections are based on the assumption that, if no reforestation of mine sites ever occurred, forest loss acreage similar to the ten years (1992-2002) of permits would occur over the future ten years.

Table IV.C-4
Estimated Terrestrial Impacts: West Virginia Portion of the Study Area

	Baseline Condition (NLCDS)	Condition from Issued Permits	Projected Future Condition*
Forest Cover (ac)	2,703,652	2,617,065	2,530,478
Forest Cover (%)	93.8	90.6	87.5
Forest Loss (ac)	—	86,587	173,174
Forest Loss from Valley Fills (ac)	—	18,338	—
Forest Loss from Mineral Extraction Area (ac)	—	45,544	—
Grassland as indication of of past mining impact (ac)	86,777	86,164	—
Quarry/strip mines/gravel pits (ac)	45,715	133,155	—

NLCDS = National Land Cover Data Set
Source: Landscape Scale Cumulative Impact Study of Future Mountaintop Mining Operations, prepared by EPA, 2002.
* Projections are based on the assumption that, if no reforestation of mine sites ever occurred, forest loss acreage similar to the ten years (1992-2002) of permits would occur over the future ten years.

There are also indirect effects related to removal of the forest associated with mining. Studies have shown that trees help remove certain elements from our air and sequester them. This process is know as "carbon sequestration." Thus the removal of forests means that those trees removed can no longer sequester carbon from the air, and depending on how the removed trees are utilized or disposed of, may re-introduce previously sequestered elements back into the air. [Chapter II.C.8.a.2.]

Another indirect effect is that, at least from a historical perspective, past mine reclamation practices have impacted the re-establishment of forests on the mine disturbance areas as described below in greater detail. When compared to pre-mine conditions, this has resulted in forest harvest cycles within the disturbed areas having been extended. Other indirect impacts also occur as the wildlife species occupying the pre-mining environmental niches are replaced by a different type of wildlife community adapted to the newly-established environment of the reclaimed mine site. Alterations of the hydrologic and terrestrial environments associated with the removal of the forest and subsequent mining are analyzed in Chapter II, III, and other sections of this chapter.

1. Consequences Common to the No Action Alternative and Alternatives 1, 2, and 3

When looking at the historical perspective of mountaintop mine reclamation between 1977 and 1997, information collected as part of this EIS indicated that the re-establishment of the forest community, either through reclamation or natural succession, was impaired [Chapter II.B.4]. At best, reforestation could only be considered marginally successful (poor survival and impaired rate of growth). In a desire to stabilize reclaimed mine sites to prevent slides, minimize erosion, maintain acceptable water quality, and achieve bond release in a reasonable time period, reclamation of mine sites created an environment that was not conducive to the establishment of trees. Reclaimed areas were heavily compacted to prevent slides, aggressive ground cover species were used to minimize erosion, and growth mediums having near to above neutral pH were selected and used to help maintain water quality. Each of these "typical" mine reclamation practices were subsequently found to contribute to the difficulties in re-establishing forest communities similar to those which existed prior to mining.

However, recent research at Virginia Polytechnic and State University (VPI) and the University of Kentucky has demonstrated that forest communities can be successfully re-established on reclaimed mine sites. Factors (such as compaction, competition from grasses, and wildlife browsing, etc.) impairing the ability to re-establish the forest on mine sites were identified and measures developed to correct these past problems [Chapter III.B.4]. Over the past few years, Kentucky, Virginia, and West Virginia have, through various regulations, advisory memorandums, etc., begun to press for use of many of the improved reforestation practices and procedures detailed in research.

Through efforts by the states, the OSM forestry initiative, and other technology transfer and regulatory incentive methods, landowners and the regulated community are becoming convinced to implement forestry post-mining land uses and on-the-ground results are meeting with some success. In Virginia, the majority of post-mining land uses proposed on coal mine sites are forestry. A study of the proposed post-mining land uses on current mountaintop mine sites in West Virginia revealed that 68% of the sites were to be reclaimed to forestry-related land uses [Appendix G; (Yuill, 2002)]. These efforts will not resolve all the problems that inhibited the successful establishment of forest communities on reclaimed mine sites. However, the research indicates that quality forest

communities that equal or exceed growth rates that existed prior to mining can be successfully and economically established on these mined sites. As the state and Federal initiatives to improve the establishment of forests on reclaimed mine sites have only recently begun to be implemented (i.e., within the last five years), it would be premature to attempt to evaluate the success of these efforts at this time. However, the recent efforts in the study area states to promote forestry land uses and implement the procedures necessary to successfully establish a quality forest community provide indications that forests can be established on many of the reclaimed mine sites in a timely manner.

In the short term, the timely re-establishment of a quality forest community on reclaimed mine sites would not prevent the various impacts associated with mining-related disturbance to forest and soils as described above and in Chapter III. When MTM/VF mining occurs, coal is extracted to help meet the energy needs of the nation. But forests and forest soils are removed; hydrologic and aquatic impacts occur; terrestrial wildlife is impacted; aesthetic and quality-of-life values are impacted, and economic costs and benefits are incurred. However, it is anticipated that, with the implementation of the research recommendations, long-term environmental and economic benefits (productivity improvements) will be realized. Environmental benefits realized would occur by reducing the number of years to re-establish a quality forest community. In other words, the mine site reclamation would result in selection and use of growth mediums more conducive to establishment of trees and tree survival and growth rates more similar to (or better than) those existing prior to mining.

Although research has demonstrated that many of the tree species present in this area can be re-established on reclaimed mine sites, it is unlikely that all forest communities existing prior to mining such as cove-hardwood forests can be restored on these reclaimed sites. As post-mined sites will likely lack the requirements of slope, aspect, and soil moisture needed for cove-hardwood forest communities, it is unlikely that these particular communities can be re-established through reclamation (Strausbaugh and Core, 1997). However, regardless of the tree species, the reduction in the time required to re-establish a forest (commercial or otherwise) equal or better than that which existed on the disturbed areas prior to mining will also provide other environmental benefits such as: 1) an improved aesthetic environment as grass-shrub habitats that typically follow mining will be more quickly replaced by forest habitats; 2) resumption of carbon sequestration; 3) resumption of forest product utilization; 4) return of forest wildlife species similar to those that were present prior to mining; and 5) resumption of more normal hydrologic cycles (e.g. evapotranspiration cycles, peak flow), etc.

As previously discussed, vegetation and soils of the forest environment are totally disturbed when an area is disturbed for the purpose extracting coal by surface mining methods. Although SMCRA regulations require salvaging and redistribution of topsoil or acceptable topsoil substitutes as a growth medium, comments were received during scoping specific to the impacts to soils as a result of MTM/VF. A study (Sencindiver, 2001) was commissioned during this EIS "to evaluate physical, chemical, and microbiological properties of mine soils developing on reclaimed mountaintop removal coal mines in southern West Virginia." Recognizing that minesoils are "developing in drastically disturbed earthen materials," the study evaluated soil development on reclaimed MTM/VF sites varying from 8 to 30 years in age. The study concluded that although the properties of the older minesoils were more similar to native soils than were the younger minesoils, in general, "the minesoils are approaching stable, developed soils and should become more like the native soils as they continue to develop." This study, presented in Appendix E, tends to support a conclusion

that impacts to soils from MTM/VF are not irreversible and that over time, soils similar to those that existed prior to mining are likely to be re-established on reclaimed mine sites.

As indicated in the discussion in Chapter IV.C.1.a., the Cumulative Impact Study in Appendix I was used to develop Tables IV.C-1 through IV.C-4. The impacts to forest and forest soils that occurred for the ten year period from 1992 - 2002 have subsequently been projected as the anticipated forest disturbance over the next 10 years (2003-2013). The tables project an estimated impact to the forest environment (vegetation and soils) in the study area from surface mining during this period at 380,547 acres or 3.4 % of the forest area that existed in 1992. So for the 20 year period from 1992 to 2013, the estimated impact in the study area would be 761,094 or 6.8% of the forest that existed in 1992. The "qualifications" of this estimate described in the Chapter IV.C.1.a., and the more recent trend data discussed in Chapter IV.B.2.a., must be considered when using this estimate. As indicated and discussed in detail in Chapter IV.B.2.a., recent changes have been made in the SMCRA and CWA programs which have resulted in reduction in the size and number of valley fills when compared to pre-1998 data. This reduction in size and number of fills would indirectly have resulted in a corresponding reduction in the number of acres of forest and forest soils impacted by MTM/VF. When the qualification statements and recent trend data are considered in totality, it is likely that the forest and forest soil impact predictions for the next ten year period will be less than the projected 380,547 acres.

2. Consequences Common to Alternatives 1, 2, and 3

Alternatives 1, 2, and 3 include Action 13. As described in Chapter II.C.8.b, this action envisions building on the recent efforts of the states and the OSM reforestation initiative by assembling the "best technology currently available" or proven "best management practices" (BMPs) for the design and implementation of mining and reclamation activities. A BMP guidance manual could subsequently be developed, in cooperation with the states and research community, for use by the regulatory agencies and the regulated community. A list of possible topics for which BMP's could be developed and a description of some of these topics is provided in Chapter II.C.8.b.

The development of a BMP manual as proposed in Alternatives 1, 2, and 3 could assist regulators in determining compliance with regulatory requirements such as selection of the best available growth medium, prevention of compaction, enhancement of wildlife habitat, and minimizing adverse impacts, to the extent practicable. As such, the overarching impacts of this action would be to expand the benefits described in the No Action Alternative beyond those who merely attend the reforestation symposia and beyond those states where the state regulatory agency has already implemented reforestation improvements.

Development and use of a BMP manual could have a number of potential benefits related to the use of trees in mine reclamation. The beneficial consequences might include:

- improving ability to establish trees and ensure the long-term success of the PMLU,
- reducing the time frames necessary for natural succession to occur,
- facilitating mine site reclamation by maximizing utilization of organic materials remaining after logging,
- enhancing wildlife habitat, and

- maximizing forest product recovery prior to mining to better meet demands for wood products and reduce the need for additional logging-related disturbances thus minimizing impacts to additional environmental resources

A number of BMPs could be developed, each of which may have economic implications for the landowners, regulatory agencies and/or the regulated community. Some BMP's may result in cost increases while others may lead to cost savings. However, the development and use of a BMP guidance manual could result in cost increases to landowners and the regulated community.

In a cumulative sense, the only difference between the No Action Alternative and the development and use of BMPs as a part of Alternatives 1, 2, and 3 is that this action anticipates broader acceptance and use of the BMPs to improve reclamation to a forest land use. The re-establishment of forests on mine sites would likely occur over a larger area, thus on a study area scale, further reducing the period required for sites to revert to forest, restore habitat, and provide forest products.

Post-mining land use (PMLU) selection is a key factor in the establishment of tree species on reclaimed mined land. Alternatives 1, 2, and 3 also include Action 14. As indicated in Chapter II.C.8.b, this action, if implemented, would have legislative authorities enact changes to SMCRA or similar State statutes, such that SMCRA regulatory authorities could require reclamation with trees as the post mining land use. If implemented, this action could further limit land use options available to a property owner under SMCRA regulations. The action could result in the more widespread use of trees as a PMLU and, from a cumulative impact standpoint, be more effective at assuring re-established values associated with a forest community following mining.

D. FISH &WILDLIFE

The southern Appalachians, of which the EIS study area is a part, have been identified by the Nature Conservancy as an important area in the United States for rarity and richness [Stein et al., 2000]. This region is known to have the highest regional concentration of aquatic biodiversity in the nation. For this reason, it is hypothesized that impacts which result in decreases in genetic diversity, as measured by loss of species, loss of populations or loss of genetic variants, may have a disproportionately large impact on the total aquatic genetic diversity of the nation. At the landscape or regional level, certain natural habitat types are especially important for the ecological functioning or species diversity of the ecosystem. Unusual climatic or edaphic (soil-based) conditions may create areas of important local biodiversity or disproportionally support ecological processes such as hydrologic patterns, nutrient cycling, and structural complexity. In general, these are remaining undisturbed natural areas, especially those that integrate the flows of water, nutrients, energy, and biota through the watershed or region (Polunin and Worthington, 1990). Headwater stream systems naturally provide these listed functions (USFWS, 1999).

Terrestrial impacts related to forest fragmentation, neotropical migratory birds, wildlife habitat loss, effects on endangered species, impacts on biodiversity, cumulative effects, and sustainability were studied and the results are in Appendix E. The effects of deforestation and forest fragmentation on plants and wildlife are also described in Chapter III.F. This chapter describes in detail the changes to the existing terrestrial environment that occur when large areas of forest community are disturbed or removed [Chapter IV.C]. These changes may be temporary until the forest recovers, or permanent if the site is developed. For a number of years to come, the forest ecosystem is replaced by a grassland and/or herbaceous/shrub vegetative community with different topographic and hydrologic conditions than the pre-mining forest. The wildlife species occupying the pre-mining environmental niches are replaced by a different type of wildlife community adapted to the newly-established environment of the reclaimed mine site.

The consequences of MTM/VF also may impact aquatic resources, including fish. The aquatic impacts were discussed above in Chapter IV.B. The results of technical studies provide insight into aquatic and impacts to fish (USEPA 2000; Stauffer and Ferreri 2002). The studies conclude that valley fills within a watershed may result in impacts to the downstream biotic community structure. A similar project undertaken under the Powell River Project in Virginia may determine whether or not impacts observed can be expected to occur on a larger regional scale [http://als.cses.vt.edu/PRP/].

1. Consequences Common to the No Action Alternative and Alternatives 1, 2 and 3

The Landscape Scale Cumulative Impact Study modeled terrestrial impacts based on ten years (1992-2002) of surface mine permit data (EPA, 2002). Tables IV.C-1 through IV.C-4 were developed from data presented in the Cumulative Impact Study [Appendix I]. The cumulative impacts to terrestrial wildlife species endemic to the MTM/VF portions of the study area would be in direct proportion to the impacts to their forest habitat. As forest habitat is impacted, the wildlife species utilizing that habitat would subsequently be impacted. In a cumulative sense, the greater the forest impact, the more widespread the impacts to terrestrial wildlife species. A description of the cumulative impacts to forest is in Chapter IV.C.

a. Terrestrial Habitat

The study area is rich in avian fauna and a number of species exist that require interior forest for successful breeding. While large tracts of intact forest are rare in the eastern United States due to a number of land use change associated reasons, the EIS study area is comprised of 92% forest. Deforestation and forest fragmentation may locally affect interior forest species such as migratory neo-tropical songbirds and other species that do not range but short distances, such as salamanders. On a regional basis though, if past practice from 1992-2002 occurs over the next decade, MTM/VF could account for 6.8% deforestation of the study area. This 6.8% represents 380,547 acres of forest directly impacted in the last 10 years, and a liberal, worst case projection of an additional 380,547 acres of forest impacted in the next 10 years, with no action. These impacts do not reflect any natural succession or reforestation efforts, that have occurred and will occur. Nonetheless, MTM/VF would result in fragmentation of the forests. The remaining forest patches may provide proper habitat to maintain the population of most of the states avian fauna; however, a few species may be put into peril because their core breeding area is within the heart of the future mountaintop mining area. Some scientists may make the value judgement that loss of these species may have more ecological importance than providing habitat for grassland species considered rare in the state.

Habitat changes will occur in the study area and these changes involve a shift from a forest dominated landscape to a fragmented landscape with more grassland habitat. This shift leads to a shift in the plants and animals of the ecosystem. For example, dry grassland species will dominate the once post-mined and forest harvested sites. This results in an overall reduction in the native woody flora, as well as a reduction in the spring herbs and other vegetative components characteristic to the study area. [Appendix E (Wood, et al, 2001; Handel, 2001)]

Wood and Edwards provide evidence that mine sites that were converted to grasslands after mountaintop mining provide habitat for a number of grassland bird species that are listed as rare in West Virginia [Appendix D]. These species are rare in West Virginia because grasslands are historically rare in the state [Strausbaugh and Core, 1997]. Providing habitat for species listed as rare may not be ecologically significant because these grassland species have substantial breeding habitat in other parts of the United States. The Dicksissel, Horned Lark, Eastern Meadow Lark, and Grasshopper Sparrow are grassland birds with breeding ranges outside of the study area.

As indicated in Chapter IV.C., Soils and Vegetation, the timely re-establishment of a quality forest community on reclaimed mine sites would not prevent the previously described impacts to terrestrial wildlife species. However, with the improvements in the ability to re-establish forests of similar species to those which existed prior to mining, the ability to re-establish wildlife communities similar to those which existed prior to mining would be enhanced. The cove-hardwood forest community is one exception that would not likely re-establish on mine sites, and it is equally unlikely that wildlife communities endemic to this type environment would return. In short, just as the time periods to re-establish similar forests are reduced, the time periods to re-establish similar wildlife communities would also diminish.

b. Wildlife Populations

Wildlife population is a measure for evolutionary change and functioning of ecosystems. However, population numbers alone do not adequately reflect the prospects for species or the continued

performance of their ecological role. Information about life history and population dynamics, such as dispersion, fertility, recruitment, and mortality rates, is critical to identifying potential effects on population persistence and ecological processes. When populations are lost, the local adaptations of these populations are lost, the ecosystem functions performed by these populations cease, and ultimately species may go extinct. In general, the risk of losing populations (and with them ecological integrity) is greatest when populations are small, but even large populations may have critical components of their life histories of population cycles that make them especially vulnerable. (EPA, 1999)

Direct and indirect impacts of population dynamics affect headwater stream systems in the EIS study area. These biotic systems are characteristically in locations with high numbers of endemic macro invertebrates, amphibians and fish. Populations tend to be small and highly specialized in the headwaters environment. Species with these traits tend to be sensitive to relatively small changes in their environment (Stein et al., 2000). Some species in headwater streams may have distributions limited to only one or several watersheds. With such a small geographic range, fill activities from one mine may impact the entire population.

MTM/VF activities may impact population dynamics through indirect as well as direct impacts. For instance, changes in contaminants or in thermal regime may affect survivorship and reproduction and impact the number of individuals available for recruitment. An increase in base flow may eliminate intermittent flow areas serving as refuge for amphibians from fish predators. The loss of autochthonous input from timber harvesting may decrease the habitat types available and may impact reproductive success for some species. Finally, egg mortality may be affected by changes in flow and/or sedimentation. Many other impact producing factors in the study area may cause environmental changes that might result in altered population dynamics, including potential extirpation of some species. Although data are lacking on the magnitude of mining impacts compared to other alterations in land use, such as forestry, the MTM/VF impacts to complex population dynamics in headwater stream systems requires additional study to detail the impacts to this system in the study area.

Preservation of genetic diversity is critical to maintaining a reservoir of evolutionary potential for adaptation to future stresses. The genetic diversity of a species is a resource that cannot be replaced (Solbrig, 1991). Genetic diversity enables a population to respond to natural selection, helping it adapt to changes in selective regimes. Evidence indicates that a reduction of genetic diversity may increase the probability of extinction in populations. Many of the factors that affect genetic diversity have been discussed for population dynamics. Extirpating populations as well as species would result in decreases in genetic diversity in the study area. Direct filling of streams may reduce the numbers of individuals of rare and endemic species, thereby reducing its genetic diversity possibly to the point of extinct. Indirect impacts from mining through alterations in water chemistry, stream flow or the aquatic thermal regime may also negatively impact populations reducing genetic diversity.

However, determinations of this type of impact is highly site-specific and, as such, are beyond the ability of this document to evaluate. Identification of these endemic populations, and as appropriate, protection measures, would be developed on a case-by-case basis as MTM/VF proposals are submitted.

While all of these factors affecting wildlife populations were not studied, other studies for the EIS evaluated the abundance of wildlife on MTM/VF sites. Grassland birds will likely increase, while many forest interior, neo-tropical migrant species will suffer losses in numbers as a result of MTM/VF. Some also believe there may be an increase in game species such as whitetail deer and turkey due to an increase in the diversification of habitats.

The Potential Ecological Condition (PEC) is an index intended to assess the ecological integrity of watersheds based primarily on the extent of large scale human disturbance and forest cover. This index was developed under the premise that songbird community composition reflects ecosystem properties of concern such as structural complexity and landscape configuration. The results of the PEC metric calculated in the Cumulative Impact Study suggest that mountaintop mining may not have a significant impact on the biologic integrity of the terrestrial ecosystems in the study area [Appendix I (USEPA, 2002)].

Although, the Cumulative Impact Study suggests that ample forest will remain in the study area under the future conditions of the No Action Alternative and Alternatives 1, 2, and 3 to maintain relatively high PEC scores, adverse impacts from MTM/VF and logging to many forest interior bird species, such as those species with breeding ranges that are restricted to or confined mostly within the study area are still possible. Portions of core breeding ranges for the Louisiana waterthrush, worm-eating warbler, and cerulean warbler are within the the study area [http://www.mbr-pwrc.usgs.gov/bbs]. Disturbances associated with mountaintop mining could potentially adversely impact each of these species breeding ranges. Researchers have demonstrated that habitat loss does not have to be total to reduce wildlife populations. Many species are "area-sensitive" and require large blocks of habitat or have other special habitat requirements that maybe affected by MTM/VF operations. Although fragments of forest may remain after mining is complete in a previously forested area, certain area-sensitive forest birds (forest interior species) may be absent or their populations reduced.

The herpetofauna will likely undergo a shift from mesic favoring salamander dominated communities along the riparian corridors of the small headwater streams and in the litter of the forest floor to a snake-dominated grassland fauna. [Appendix D; Chapter III.F.7; Wood and Edwards, 2001]. Salamanders are an important ecological component in the mesic forests of the study area and are often the most abundant group of vertebrates in both biomass and number (Burton and Lykens, 1975; Hairston, 1987). Ecologically, salamanders are intimately associated with forest ecosystems, acting as predators of small invertebrates and serving as prey to larger predators (Pough, et al., 1987). Petranka (1993) presented a conservative estimate that there are about 10,000 salamanders per hectare (about 4,050 per acre) of mature forest floor in Eastern forests. A reduction in salamander populations may have negative impacts on the species that depend upon them in the food web.

c. Aquatic/Terrestrial Interface

Chapters III.C. and III.D. of this EIS describes biotic interactions common in headwater streams and various vertebrate species including birds, salamanders (including newts), and mammals which require interactions with the aquatic environment in order to maintain their life cycle. Biotic communities have been demonstrated to occur in the uppermost reaches of watersheds, even in ephemeral stream zones which flow only as a result of rain or snow melt. Under all alternatives, the

biota in these reaches are at risk from valley fills. Filling would eliminate all aquatic and aquatic-dependant interactions that would formerly have occurred in the filled area. In areas downstream from fills, changes in the macroinvertebrate and fish communities have been observed (USEPA, 2000; Stauffer and Ferreri, 2002). Any change in community composition may impact the biotic interactions but these interactions were not studied as part of this EIS because they are often difficult to demonstrate.

Other human activities and development in the study area may cause environmental changes that would result in alterations or simplifications in biotic communities and associated biotic interactions. Although data are lacking on the magnitude of mining impacts compared to other alterations in land use such as forestry, the permanent nature of filling would suggest that MTM/VF impacts to biotic interactions in headwater stream systems, including interactions linking terrestrial biota to the aquatic environment, may constitute a irreversible impact to this system in the study area.

d. Fish Populations

According to Stauffer and Ferreri (2002), the EIS study area is unique and important in the evolution and speciation of North American freshwater fishes [Appendix D; Chapter III.]. Fifty-six species of fish, including two hybrid sunfishes, were collected within several watersheds in the EIS study area. The study determined that small headwater streams harbor populations with unique genetic diversity. These headwater stream populations have the greatest potential for natural selection processes that may result in development of new species/subspecies.

Comparison of the numbers of total species and benthic species on unmined sites and filled sites in Kentucky and in the New River Drainage indicate that MTM/VF has had an effect on the number and composition of the fish communities in these streams. Streams classified as filled had lower numbers of total species and benthic species than unmined streams in both areas.

e. Threatened and Endangered Species

Endangered, threatened, candidate, and special concern species known to inhabit the study area were identified through correspondence with the appropriate Kentucky, Tennessee, Virginia, and West Virginia state agencies and the FWS. Letters requesting T&E terrestrial species information were sent to the Kentucky Natural Resources and Environmental Protection Cabinet, the Tennessee Department of Environment and Conservation, Virginia Department of Conservation and Recreation, and the West Virginia Division of Natural Resources. Responses to these letters included lists of Federal and state listed threatened, endangered, and sensitive species broken down by county. These responses and habitat information are summarized in Appendix F of this EIS.

On September 24, 1996, the FWS concluded formal consultation with OSM pursuant to Section 7 of the ESA on MTM/VF operations conducted under state and Federal regulatory programs adopted under SMCRA and its implementing regulations. This programmatic consultation lead to the issuance by the FWS of a Biological Opinion (BO) and conference report that found surface coal mining and reclamation operations conducted in accordance with properly implemented state and Federal regulatory programs under SMCRA would not be likely to jeopardize the continued existence of listed or proposed species, or result in the destruction or adverse modification of designated or proposed critical habitats.

In addition to the SMCRA program coordination with FWS to implement the 1996 BO and ensure ESA compliance, the COE must consult with FWS on issuance of CWA Section 404 permits. FWS and OSM have also developed an endangered species training course to inform State regulatory agencies and OSM staff about the requirements of the ESA and the 1996 BO, and foster a cooperative working relationship. Implementing these ESA program controls serve to assure appropriate dealings T&E species and their critical habitat.

Currently, the Federal agencies are conducting informal consultation with FWS to determine the extent to which the proposed actions included in the preferred alternative may affect federally listed species or critical habitats that are in the EIS study area. EPA is in the process of writing a Biological Assessment (BA) that will identify Federally listed T&E species which are likely to be adversely affected by actions included in the preferred alternative. The BA under development for this EIS will consider the consequences of several of the Federally-listed T&E species cited in Appendix F that are found in some parts of the study area and that may be affected by MTM/VF. The initial list of species to be considered include the following:

Applachian monkeyface pearly mussel (*Quadrula sparsa*)
Birdwing pearly mussel (*Conradilla caelata*)
Blackside dace (*Phoxinus cumberlandensis*)
Clubshell (*Pleurobema clava*)
Cumberland bean pearly mussel (*Villosa trabalis*)
Cumberland combshell (*Epioblasma brevidens*)
Cumberland monkeyface pearly mussel (*Quadrula intermedia*)
Cumberland elktoe (*Alasmidonta atropurpurea)*
Dromedary pearly mussel (*Dromus dromus*)
Indiana bat (*Myotis sodalis*)
Little-wing pearly mussel (*Pegias fabula*)
Northern riffleshell (*Epioblasma torulosa rangiana*)
Oyster mussel (*Epioblasma capsaeformis*)
Pink mucket pearly mussel (*Toxolasma cylindrella*)
Purple bean (*Villosa perpurpurea*)
Rough rabbitsfoot (*Quadrula cylindrica strigillata*)
Shiney pigtoe (*Fusconaia cor (=edgariana)*)
Tan riffleshell (*Epioblasma florentina walkeri*)
Virginia Northern flying squirrel (*Glaucomys sabrinus fuscus*)

Although all of the listed T&E species in Appendix F will be considered in the BA, special attention will be given to the species listed above. Measures to avoid adversely affecting the Federally-listed species will be considered in the BA. Information about the findings of the BA and the informal consultation will be provided in the final EIS.

2. Consequences Common to Alternatives 1, 2, and 3

All three action alternatives provide for mitigation of functions lost by valley fills covering headwater streams. Mitigation provides opportunities to maintain and improve watershed health, provide for continued or renewed genetic diversity, and restoration of crucial aquatic/terrestrial interface.

The forest loss under the alternatives may be less because of the increased focus to reclaim post mined lands with trees [Chapter II.C.8; Actions 13 and 14]. Such future conditions under Alternatives 1, 2, and 3 would provide opportunity for maintaining the diverse avian fauna of the study area, while at the same time providing substantial breeding habitat for disjunct populations of the rare grassland species. Reforestation or creation of riparian zones as part of mitigation will also aid in restoring contributions of woody materials and leaves for macro invertebrates and downstream energy transport.

There are no significant differences among the No Action Alternative and Alternatives 1, 2, and 3 in terms of their ability to protect T&E species. However, the EIS contains provisional Action 17, should the BA, described above, identify particular measures are needed to fulfill ESA provisions [Chapter II.C.11; Action 17].

E. AIR QUALITY

As described in the Chapter III.V, potential air quality issues of airborne dust and fumes generally result from inhalation of particulate matter, fugitive dust, and re-entrained dust emanating from the mining operations and hauling. Direct impacts to air quality are localized within the immediate area of the mining site and are temporary in nature. Increased awareness of the dust emitted from hauling operations in recent years has improved air quality problems associated with hauling in the vicinity of the mining operations. Air quality programs are described in Chapter II.C.9 and Appendix B.

1. Consequences of the No Action and Action Alternatives

The environmental consequences of MTM/VF to air quality can be considered locally, regionally, and nationally. From the perspective of local consequences, fugitive dust and particulates, fumes released during blasting, and emissions from vehicles and machinery were considered. From a regional perspective, the cumulative effects of these impacts from nearby sources were considered. No irreversible and irretrievable impacts occur with this issue. The forty-two monitoring stations within the study area reported acceptable air quality for all criteria air pollutants in recent years, with the exception of ozone in Boyd and Greenup Counties, Kentucky.

EPA and the states are responsible for Clean Air Act (CAA) implementation regarding air quality [Chapter II.C.9.a.1]. The CAA is the comprehensive Federal law that regulates air emissions from area, stationary, and mobile sources. This law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. The development of state implementation plans (SIP's) applicable to appropriate industrial sources in the state are designed to attain and maintain applicable NAAQS.

The Federal government generally does not have the authority to regulate fugitive emissions that are not associated with a *permanent stationary source* [42 U.S.C. 7479]. Mountaintop mines are not permanent stationary sources; and, thus far, have not been considered to meet the criteria for *major source* air quality permits, i.e., defined for particulate matter as sources which emit at least 250 tons/year [42 U.S.C. 7661]. However, because the SIPs also were required to contain a permitting program for major and minor sources, fugitive emissions can be regulated under the state SIPs, state permitting programs, and select state regulations, depending upon the facility composition.

a. Fugitive Dust

Fugitive dust usually refers to the dust put into the atmosphere by the wind blowing over bare soil, plowed fields, dirt roads or desert or sandy areas with little or no vegetation. In the case of MTM/VF, re-entrained dust is temporarily put into the air by activities such as vehicles driving over dirt roads and dusty areas, excavation of overburden, and blasting. The emission rates of fugitive dusts are highly variable and dependent on the prevailing atmospheric conditions, including wind speed and direction.

Previous EPA studies have found that mining activities such as drilling, blasting, coal removal, haul trucks, material handling and storage, truck loading and unloading, and bulldozer activities cause dust. Both drilling and blasting emissions are considered to be small contributors to particulate matter emissions, in comparison with other sources of emissions in this category. The most

significant sources of emissions for these types of activities are overburden removal and haul trucks. According to the EPA report, haulage can account for over 50% of the particulate emissions at surface mining sites. Bulldozer activities can also account for significant particulate emissions at levels (about 4% of the total emissions). Truck loading and unloading are considered to be minor contributors to overall emissions. (USEPA, 1991)

b. Respirable Dust

Particulate matter (PM) of concern for protection of lung health are the fine particles. PM in the form of respirable dust are particles with aerodynamic diameters less than 10 microns. This size of airborne dust is capable of entering the lungs if inhaled. According to the American Lung Association, particles of special concern are less than 2.5 microns in diameter. These particles are more easily inhaled than larger sized particles and can either become embedded deeply into the lungs or absorbed into the bloodstream. Inhalation of particulate matter air pollution is particularly harmful to sensitive members of the population who have pre-existing conditions such as asthma and chronic obstructive pulmonary disease. These particle sizes are typically of concern for workers on the mine site and regulated by the Occupational Health and Safety Administration and MSHA. Most particulates from surface coal mining and reclamation operations exceed 10 microns.

Emissions from blasting and drilling are minor contributors and are mostly a concern for the workforce. This is particularly true for drilling when the rock has significant crystalline silica content and the drill operators and helpers may be exposed to large amounts of respirable crystalline silica. Such exposure places these workers at high risk of silicosis. However, the high particulate concentrations associated with drilling affect a limited area and are generally not a concern for surrounding communities. In considering the impact upon communities, the major sources of emissions at surface mines involve scraper travel (not commonly used in Appalachia), overburden and coal removal (by drag lines, shovels, and loaders), truck haulage, and vehicle traffic. Vehicle traffic from and to mines may be a particular concern due to dispersal from the mine haulage roads and entrainment of the load due to improper or no load covering during travel from the mine to the preparation plant or loading terminal and return.

A limited study of the dust from surface mines is in Appendix G. The study found that dust transport following blasting occurred only over short distances. However, SMCRA regulatory agencies in the EIS study area have dealt with several citizens' complaints regarding dust from surface mining. In some cases, dust complaints may be beyond the scope of regulatory authority and present a nuisance. Citizens were recently successful in a West Virginia civil action regarding dust nuisance from a coal storage area on a surface mine.

c. Blasting Fumes

Potential health effects associated with surface mining operations include the potential inhalation of toxic fumes generated from the blasting operations. Blasting operations may involve the release of fumes including carbon monoxide, nitrogen dioxide, nitric oxide and ammonia. The type and amount of fumes released is dependent on the frequency and type of blasting operation conducted for the particular mining operation. According to research published by the National Institute for Occupational Safety and Health (NIOSH), over the past 30 years, blasters have switched to using less expensive blasting agents such as ammonium nitrate/fuel oil (ANFO) mixtures. Ammonia is

released during this combustion process. Exposure to ammonia may cause eye and respiratory irritation. A study of blasting fumes performed in conjunction with the EIS found that fume transport did not extend beyond the permit boundary.

2. Consequences Common to Alternatives 1, 2, and 3

Each of the action alternatives includes an action proposal to evaluate current programs for controlling fugitive dust and blasting fumes from mountaintop mining/valley fill operations, and develop BMPs and/or additional regulatory controls to minimize adverse effects, as appropriate. Under this action, meteorological and physical conditions which can exacerbate dust or blasting fumes, state-of-the-art techniques currently used in the mining industry to control dust and fumes, and appropriate regulatory improvements that can be implemented to monitor and control emissions would be identified.

Under the action alternatives, surface coal mining operators would have access to a central source for state-of-the-art information on techniques to control air quality problems that may not be available under the No Action Alternative. This information, if utilized in the day-to-day operations, could reduce the potential for or, in some cases, eliminate citizen complaints regarding dust and blasting fumes. The action also considers the development of additional regulatory controls, as appropriate to minimize adverse effects. While operators may not embrace the BMPs in the action alternatives, the presence of information, coupled with encouragement to utilize the practices by the regulatory authorities when air quality issues arise, have greater potential to minimize adverse effects.

F. ENERGY, NATURAL, OR DEPLETABLE RESOURCE REQUIREMENTS

The surface mining of coal involves an irreversible commitment of resources. As the coal is mined and placed into commerce for energy or metallurgical production, this resource is not renewable and the remaining coal reserves are finite. On the other hand, surface mining is a temporary use of the land and, with proper mining and reclamation techniques, the land is not irretrievable for a variety of future land uses.

The three action alternatives and the No Action Alternative may also provide significant environmental benefit, if mitigation proves infeasible in certain locations, causing no mining to occur. If fill minimization/mitigation is difficult or impossible because of the application of the CWA 404(b)(1) Guidelines some coal reserves may not be minable. If coal resources in the study area are rendered economically unrecoverable, they may never be mined or not be mined until coal market conditions or mining/reclamation technology provides means to develop the resource in compliance with applicable state and Federal regulatory requirements. Some limited number of reserves may be recoverable by underground mining or a combination of contour and auger/highwall mining. Such types of underground or surface coal mining techniques do not recover as much of the resource a larger-scale surface area or mountaintop removal mining methods.

Coal mining provides over 50% of the electrical generation capacity for the nation, and, in states within the EIS study area, more than 90% of electricity comes from Appalachian coal. Nevertheless, resources in U.S. coal basins within or outside of Appalachia and in other countries exist to offset lost reserves from the study area, if market conditions change for regulatory or other reasons. However, economic impacts resulting from decreased coal mining, could be locally significant [Chapter IV.I.].

Precise estimates of the magnitude of change anticipated from regulatory actions impacting mineral economics are difficult to calculate. The difficulty occurs because the decision of when and where remaining coal reserves may be mined is controlled by numerous complicated factors, such as mineral and surface ownership, market demands for particular coal quality, and the availability of investment capital, equipment, labor, etc. Also, the amount and location of remaining reserves presents various alternatives for future mining and the impact of regulatory costs are highly site specific. To perform such an analysis would require detailed analysis of all remaining minable properties. It is not practical to analyze on that scale and creation of reliable resource maps on any scale is cost prohibitive.

G. CULTURAL, HISTORIC, AND VISUAL RESOURCES

Cultural, historic, and visual resources are discussed in Chapter III.P, R, S, T, and U. Cultural resources are the fragile and non-renewable remains of human activity. They are found in sites, districts, buildings, and artifacts that are important in past and present human events. Cultural resources are arbitrarily divided into historic and prehistoric cultural properties and traditional "way of life" (lifeway) values, although they are part of a continuum of human use and occupation of the land.

A traditional lifeway value is important for maintaining a traditional system of cultural practice, religious belief, or social interaction for a contemporary ethnic or cultural community. Shared traditional lifeway values are abstract, nonmaterial, ascribed ideas that cannot be discovered except through discussions with members of the particular group. Lifeway values may or may not be closely associated with narrowly-defined locations. The Library of Congress provides an online collection for West Virginia which includes extensive interviews on native forest species and the seasonal round of traditional harvesting (including spring greens; summer berries and fish; and fall nuts, roots such as ginseng, fruits, and game). The information documents community cultural events, such as storytelling, baptisms in the river, cemetery customs, and the spring "ramp" feasts using the wild leek native to the region. Interpretive texts outline the social, historical, economic, environmental, and cultural contexts of community life, while a series of maps and a diagram depicting the seasonal round of community activities provide special access to collection materials [http://memory.loc.gov/ammem/cmnshtml/cmnshome.html]

Forests provide the basis for a multi-billion dollar timber industry and are a vital part of the cultural heritage of the region. Many plants found in the forest have contributed to the region's remarkable culture. Herbs such as ginseng are used globally for medicinal purposes, and are harvested to support a local non-timber forest industry. As isolated mountain hollows fostered the evolution of rich species diversity, they helped to preserve cultural heritage and create a sense of self-reliance and independence within the people. [CVI, 2002]

This EIS study area is part of the Mid-Atlantic Highlands region that features some of the most historic landscapes in the country. Native American populations existed 15,000 years prior to arrival of ancestors of the citizens living in the study area today. Indian artifacts, burial mounds, camp sites, and related archaeological sites are scattered in the study area, most significantly in the larger floodplain valleys. Many battles of the Civil War were fought in the Appalachian countryside and pre- and post-Civil War structures and encampments may occur in some locations within the study area.

Following the crossing of the mountains by early settlers, towns and cities formed along the river valleys and became significant centers for trade and industry. Before the discovery of coal, salt brines, oil and gas, timber, glass making and other farming and trading developed the local economies. Settlers began dispersing to other ridge tops and stream valleys surrounding the towns and cities. With the discovery of coal, large land holdings were purchased for rich mineral rights (coal, oil, gas, etc.). During the industrial revolution, the demand for coal for coke and steam began to draw mining employees into coal camps. These coal camps formed the cultural and social hubs for Appalachian residents up through the first half of the twentieth century and are still the roots for

many of the inhabitants today. These coal camps and the large land holdings have tended to control the cultural and historical resources in the region.

Coal mining practices have profoundly affected the communities and residents of the Appalachian coalfields since coal mining first commenced in the region. Sections III.U.1. through III.U.4. provide an overview of the past and current interaction between the coal mining industry and the residents of Appalachia. A decline in the physical state of the community may affect the economic status of local residents. Coal companies frequently built and maintained local infrastructure, from housing to plumbing and even churches, in the coal towns of Appalachia in varying degrees of quality. Today, many coalfield communities not only receive revenue from taxes on coal property and employment, but also donations of money, land, and company equipment to support civic organizations.

Appalachian coalfield residents have a unique social and cultural connection to the natural environment. For coalfield residents, the quality of the natural environment is important both as a source of income and an integral element of Appalachian culture. Sections III.U.5. and III. U.6. present an overview of the relationship between the natural environment, Appalachian culture, and coal mining. Mining effects may compound and ultimately affect the human environment in ways such as land use and potential development, as described in Chapter III.S.; historic and archaeological resources, as described in Chapter III.T.; and the cultural, social, and economic importance of existing landscape and environmental quality, as described in Chapter III.U.

The value of prehistoric and historic properties is intrinsic and may be protected or documented under the National Historic Preservation Act (NHPA). Their preservation may stabilize neighborhoods, stimulate private investment, provide affordable housing, revitalize downtown activities, attract tourists and enhance community pride. If MTM/VF projects may impact historic properties, the projects are coordinated with the State Historic Preservation Office (SHPO). The mission of the SHPO is to encourage, inform, support, and participate in the efforts of people of the state to identify, recognize, preserve and protect prehistoric and historic structures, objects and sites.

The aesthetic quality of a community is composed of visual resources; i.e., those physical characteristics that make up the visible landscape, including land, water, vegetation and manmade features. Visual impacts affect communities from two perspectives: 1) the view from the site, and 2) the view of the site. The view from the site is from the public perspective and leaves a lasting impression of the community, are or regional on the visitor as well as residents. The view of the site by the residents contributes to the feeling of community value and pride. Visual impacts of an area are ascertained by defining the visual environment, identifying key views, analyzing the resources and community responses, depicting the project appearance, assessing the visual impacts, and then developing mitigation measures.

1. Consequences Common to the No Action and Alternatives 1, 2 and 3

Under all four alternatives, local setting for cultural, historic, and visual resources continue to be at risk from MTM/VF activities that may result in a potential impact to those resources. Coordination with the SHPO on impacts to prehistoric and historic properties will provide mitigation in the form of permanent documentation. However, existing controls are judged adequate to protect cultural and

historic resources. No distinction can be made between the No Action Alternative and the three action alternatives as they affect cultural, historic, and visual resources in the EIS study area.

All alternatives may continue to displace local communities in essentially equal amounts, since the alternatives are based on process differences and not directly on measures that restrict the area of mining. However as review processes are improved and enhanced, there should be a greater level of consideration of cultural, historic and visual resources.

Visual impacts will continue to occur, both from MTM/VF, as well as other activities such as roads, and residential/commercial development. These impacts occur to residents and visitors in the form of changes to the viewscape as seen from highways and impacts seen from air travel. Mitigation for these impacts may occur in the form of reforestation in some instances, however, some visual impacts may be permanent due to post-mining development.

As communities are displaced for whatever reason, including MTM/VF, local crafts, skills, and folk lore may be diminished and may be lost. However, all alternatives will produce indistinguishable indirect impacts in this regard.

H. SOCIAL CONDITIONS

From 1980 to 1990, the total population of the counties in the study area fell by over 140,000, from 2.11 million to 1.97 million, a 6.7% decrease. In contrast, the population of each of the states, with the exception of West Virginia, grew over this period. Regarding West Virginia, the study area counties lost population at a substantially greater rate than the state overall, 1.4 percent per year compared to 0.7% per year for the state. Census estimates for 1998 indicate that the study area's population levels have slightly rebounded to total 2,014,466. Tennessee is the only State in which the study area counties have regained their 1980 population. Total population in the West Virginia study area has declined from 1990-1998, although at a slower rate than the previous decade. [Chapter III.P]

Income statistics from the 1980 and 1990 Censuses indicate that the study area, as a whole, has a starkly lower income than the individual states. Just 4 of the 69 study area counties had a per capita income exceeding its state average per capita income in 1990. Another measure of economic well-being is the estimated percentage of the population with an income below the poverty level. Census statistics for 1980 and 1990 depict a poverty problem throughout most of the EIS study area. Over the entire study area, only four of the counties had a lower poverty rate than their respective state and only ten had a poverty rate below twenty percent in 1990. In twenty-four of the study area counties, over one in every three residents was estimated to live below the poverty level. The demographics in the EIS study area are discussed in detail in Chapter III.P.

Traditionally, many employment opportunities in the EIS study area have been in mining, forestry, and agriculture sectors; and industries requiring neither major urban centers nor knowledge in areas such as advanced computer technology. These industries have now declined, or have phased out workers through increased mechanization and operational efficient. [CVI, 2002] The study area counties nearly all show decreases in unemployment rates from 1990 to 1998, and many of the counties show greater improvements than their state average for the period. On the other hand, many study area counties had increases in unemployment rates for the preceding period (1980-1990), or had slower improvements than the state average. Taken together, the changes for the two periods suggest that the study area counties lagged the states in the 1980's in employment improvements and have begun "catching up" in the 1990's. [Chapter III.Q.] The persistence of high employment in the more isolated areas suggested that new and growing industries are not being attracted to take advantage of the available labor force [CVI, 2002].

Coal mining practices have profoundly affected the communities and residents of the Appalachian coalfields since coal mining first commenced in the region. Chapters III.U.1. through III.U.4. provide an overview of the past and current interaction between the coal mining industry and the residents of Appalachia. Appalachian coalfield residents have a unique social and cultural connection to the natural environment. For coalfield residents, the quality of the natural environment is important both as a source of income and an integral element of Appalachian culture. Chapters III.U.5. and III. U.6. present an overview of the relationship between the natural environment, Appalachian culture, and coal mining. Activities directly related to coal mining other than employment, such as increased traffic, air and water quality impacts, flooding and changes in the natural environment, affect the socio-economic conditions in the EIS study area. Because of the topography and terrain in steep slope Appalachia, flooding occurs in severe weather conditions. The

environmental affects of flooding are described in Chapter III.G., and the air quality impacts can be found in Chapters III.V. and III.W. and Appendix G.

While company towns existed in many parts of the United States in the first half of the 20th century, the effects of coal company towns in the Appalachian Mountains were more far reaching. The mining company controlled nearly every essential aspect of community life, from work, to shopping, education, retail merchandising, and medical care.

The social structure of these company towns was impacted by the paternalistic nature of the relationship between the company and the residents, resulting in a highly dependent relationship for the residents. Research indicates that this typical company town relationship has both psychological and physical manifestations. The nature of company towns has been documented across numerous industries; however, the relative isolation of the communities, the predominance of the coal industry and the relative poverty of the region prior to industrialization all arguably contribute to a more pronounced community structure based on company paternalism.

The economic dependence of the region on its exhaustible coal resources, its need to diversify, and its need to further develop the human resources and infrastructure to support economic development are widely recognized. Most leaders are also keenly aware that its coal resources are its best source of leverage for investments needed to build an economy that can continue to flourish after the inevitable decline of coal mining [Chapter III.R.].

Two of the factors most often cited as hindering economic development in Central Appalachia are the rugged terrain and the poor access. The steep slopes and the narrow, flood-prone river valleys severely constrain the available supply of developable land. The use of land after coal mining has been completed may include residential and/or commercial development. Building on and use of this relatively rare flat land could provide jobs from construction, service and commercial industries, and tourism. Changes in land uses not only affect the local social climate and tax base, but affect private property rights as lands are developed and sold.

Changes in terrestrial and aquatic habitats will affect activities such as hunting, fishing, and bird watching. The recreation use of the area by residents and tourists is discussed in Chapter IV.J.

1. Impacts Common to the No Action and Alternatives 1, 2 and 3

The environmental consequences discussed throughout Chapter IV would have an effect on the social conditions of the area. Impacts to aquatic resources affect drinking water and fisheries, impacts to terrestrial resources affects land use and development, viewsheds, wildlife use and recreation which all have a bearing on social and cultural impacts. Requiring avoidance of high quality aquatic habitats and adequate mitigation, will improve water quality in the watersheds. Mining practices affect the local culture and directly impact the economy through employment opportunities. The number of mining jobs is related to the amount of coal produced. Coal-related jobs will likely be lost as the existing coal reserves are depleted and/or if coal mining productivity increases. [Appendix G; Chapter III.P-Q]

The agencies recognize that, in spite of enforcement of the existing regulations and implementation of the recent program improvements, blasting concerns/complaints will continue. Concerns and

subsequent complaints are likely to decrease as a result of the identified recent program improvements. However, when mountaintop mining operations are near residences and populated areas, complaints, particularly those related to noise and vibration of homes (nuisance impacts), may still occur in relatively high numbers. Although regulations provide a limited ability to control nuisance impacts (for example blasting may typically occur only between sunrise and sunset), these nuisance-type concerns will continue to have periodic adverse effects on the quality of life of residents living in close proximity to the mine sites. The regulations were designed to minimize damage potential and only indirectly address nuisance; however, citizens may exercise their right to take civil action against a mining operation for nuisance-related concerns. There have been court cases in the coalfields where mining activities have been ordered to adjust operational procedures (i.e., above-and-beyond existing regulatory program controls) to reduce nuisance.

2. Impacts Common to Alternatives 1, 2, and 3

The actions in the three action alternatives are projected to have positive social benefits through the improved regulatory processes and coordinated public participation. All three action alternatives would facilitate a better understanding by the public of the regulatory process and therefore facilitate their input regarding social concerns that should be factored in permit decision making. This improved efficiency would result in mining companies having more predictability in their planning processes, resulting in reduced costs and time. The No Action Alternative would continue the existing regulatory framework.

Additional water quality data collection and analysis may result in new water quality standards, if necessary. Development of BMPs to centralize the best technical information for aquatic mitigation and reforestation [Chapters II.C.6 and II.C.8.], as well as the two actions discussed below, will provide predictability and better understanding for residents in the area of the effects of MTM/VF.

Implementation of Action 15 [Chapter II.C.9.] to evaluate and coordinate current programs for controlling fugitive dust and blasting fumes from MTM/VF operations, and develop BMPs and/or additional regulatory controls to minimize adverse effects, as appropriate. Under this action, EPA, OSM, state air quality agencies, and state mining agencies would identify 1) meteorological and physical conditions which can exacerbate dust or blasting fumes; 2) state-of-the-art techniques currently used in the mining industry to control dust and fumes; and 3) appropriate regulatory improvements to minimize adverse affects, as appropriate. This action could result in positive changes in operations to control air quality impacts near MTM/VF that may address social concerns.

Implementation of Action 16 [Chapter II.C.10.b.] would result in the identification of guidelines and methodologies for calculating peak discharges and evaluating downstream flooding risk. Modeling and other recommended approaches for peak runoff determinations could be discussed and the proper design storm event for evaluation could be suggested. This action would result in improved designs to reduce the risk of flooding to homes and businesses downstream of MTM/VF operations.

Since all of these actions would be implemented in Alternatives 1, 2, or 3, no distinction can be made between and among these alternatives as they affect social impacts.

I. ECONOMIC CONDITIONS

1. The Role of Coal in the Economy

The interaction of coal in the economy is driven directly by the energy market of the nation. Reliable, inexpensive energy is a crucial component to local, regional, national, and world economies. Setting public policy to balance environmental protection and energy needs is not a simple matter for Congress, the agencies implementing Federal law, state legislatures, or state agencies implementing state or Federal law. Normal supply and demand principles govern the energy market. For instance, the type of coal needed to comply with the Clean Air Act also influences demand. If a certain type of coal is required to meet clean air requirements and is more expensive to mine, then the cost of electricity to consumers will go up.

As long as coal is required to supply a dominant portion of local and national energy needs, the ability to extract low sulfur coal reserves efficiently and cost-effectively will occur somewhere in the nation (or the world) to meet energy demands and clean air standards. Higher mining costs due, in part, to environmental compliance (e.g., material handling, costs of mitigation, less-efficient mining methods to minimize impacts, inaccessibility of large reserves due to impact avoidance, etc.), will result in coal supplies originating from coal basins outside this EIS study area where compliance can occur. If mining costs increase too greatly within the EIS study area, mining employment would drop and tax revenue from coal would decline. Commensurate school closings, diminished state and local government services, etc. would occur. A shift to other industries (such as services, tourism, outdoor recreation, etc.) and some exodus of job-seekers to other regions of the country would occur if lower-salaried jobs are the dominant source of employment. The remaining population in the coalfields may be older and poorer as this long-term transition from coal occurs until or if other sources of employment, revenue, etc. supplant coal economic influences. This process is similar to what has occurred in other parts of the country as the steel industry declined due to foreign competition. These economic shifts have been repeated locally in numerous instances when employers or a primary industry sector decline, go out of business, or move.

If the reliance of the U.S. on coal for electricity is not supplanted by other fuel sources (gas, wind, solar, nuclear, fuel cells, other new technologies), the demand for central Appalachian coal will likely increase at some point in the future. This demand will occur as other low sulfur coal resources in the country diminish and/or more cost-effective and/or "environmentally-friendly" mining techniques are developed. Renewed demand might require more costly mining and more costly electricity with subsequent ripples in the economy as the loss of inexpensive energy influences other industrial sectors.

Central Appalachian coal currently meets air quality standards but cannot compete very effectively with Powder River Basin coal due to mining costs, reserve size, and economies of scale. Productivity increases in central Appalachia spurred by competitive pressure leaves thin profit margins and little attraction of investment capital. Additional costs of environmental compliance will undoubtedly shift some portion of production demands for compliance coal outside of the EIS study area.

Increased environmental costs due to avoidance, fill minimization, and compensatory mitigation to offset unavoidable aquatic impacts have not been a consistent factor in environmental compliance in the EIS study area until the 2002 renewal of NWP 21. These increased costs, discussed in the next section, will push mining companies, if possible, to try and avoid streams and find other places to place excess spoil—or, to "high-grade" already dwindling reserves in order to meet demand. However, even this shift in approach will be difficult, because some segment of the coal industry

has capital tied up in larger equipment that cannot economically mine with smaller fills or longer haulage distances. New capital will be required to "re-tool" in order to conduct more contour/auger mining to reduce valley fill sizes, lower mitigation costs, and still meet coal market demand. These requirements could be difficult for some companies to fulfill and these companies may not be able to secure capital for new equipment, open new mines, or exploit existing reserves.

The influence of coal mining on the central Appalachian economy, including income, employment, and tax base, is discussed briefly below and in more detail in Chapter III.Q. Coal mining earnings within West Virginia are 5 % of total state income (3% of employment); just over 1% of total earnings and employment in Kentucky, and less than 1% of employment and income in Virginia and Tennessee [Chapter III.Q.2.a-b.]. While the coal mining influence state-wide is a relatively low percent of employment and income, it is a considerable influence in certain study area counties. For instance, coal-related earnings have the highest influence in Boone County, West Virginia, Buchanan County, Virginia, and Knott County, Kentucky, where coal-related earning comprise 60, 33, and 42% of county earnings, respectively. Surface mining employment study area wide represents 25% of mining employment, but declines in surface mining production typically result in some amount of commensurate increases in underground production and employment. Shifts in coal mining employment or production in counties with higher percentages of mining earnings can have proportionate effects on the county tax base [Chapter III.Q.2.c]. In West Virginia, for example, 34% of property taxes collected come from coal. Schools rely on these property taxes to supply around 30% of district budgets.

2. Economic Effects of Smaller Valley Fills or Alternatives to Fills

Excess spoil disposal is most cost-effective for a MTM/VF operation at a point as close to overburden removal as possible. Valley fill site selection reflects this factor. Abandoned mine benches, reclaimed mine sites, or active mining areas may accommodate some volume of excess spoil, reducing the size of valley fill sites. However, haulage and material handling costs somewhat limit the practicality of using these storage alternatives to valley fills. As required by the CWA Section 404(b)(1) Guidelines, an applicant must demonstrate that alternatives to valley fills and minimized valley fills have been considered in order to properly balance practicality with project purposes.

It is noted that costs of compliance with statutory performance standards and regulatory requirements are not a basis for relaxing the standards to accomplish any particular MTM/VF project. These types of costs were projected in documents prepared as part of other CWA and SMCRA regulatory implementation and are not restated in detail here. Such costs are only generally relevant to this EIS because the alternatives look at different ways to coordinate decision making, not different ways to meet existing regulatory requirements. Implementation of any future agency action proposed by the EIS, upon filing of a record of decision following the final EIS, will include independent NEPA, legal, and regulatory analysis of the relevant economic consequences of the action. Studies related to the impacts of restricting valley fill size on production, employment, and electricity costs are in Appendix G. Avoidance and fill minimization requirements of the existing CWA Section 404 program may present the most cost-sensitive economic influence to mining costs. Therefore, generalized or relative costs associated with the compliance are illustrated in this section for consideration by the decision makers in light of other costs that could be associated with actions considered in the EIS.

While the economic studies on the projected effects of valley fill restriction in Appendix G are subject to some limitations and do not directly relate to the alternatives analyzed as part of this EIS, they indicate that valley fill size is an important determinant of mining feasibility. The existing program and the alternatives proposed in this EIS contain the common requirement that an applicant must avoid headwater streams and minimize valley fills where avoidance is not possible. Therefore, the studies in Appendix G provide indirect indications of the roll that avoidance and fill minimization may play in selection of mining methods, equipment, and the exploitation of the remaining surface coal reserves.

These studies are based on the mining engineering consideration of the number of cubic yards (cy) of overburden material removed per ton of coal recovered to determine mining feasibility (overburden ratio). Larger equipment can move more cubic yards of overburden less expensively than can smaller equipment. Accordingly, drag lines can reach deeper coal reserves than can truck-and-shovel equipment, which can reach deeper coal reserves than truck-and-loader equipment. Similarly, higher overburden ratios may create proportionately greater amounts of excess spoil. Therefore, operations mining larger or deeper reserves may require larger fills to accommodate the excess spoil. Reduction of available fill space may entail use of different equipment, alternative backfilling and grading plans, and/or result in incomplete recovery. Such differences in available excess spoil storage can adversely affect mining costs and production. Information relative to these differences and discussions on mining methods, planning/feasibility, excess spoil disposal, and reclamation are provided in Chapter III.I, J., K., and L. Economic influences due to available valley fill storage are briefly discussed below.

It is reasonable to presume that required mitigation costs (i.e., to offset valley fills) will result in future MTM designs with reduced valley fill sizes. The economic studies in Appendix G evaluated absolute fill restrictions to specific watershed sizes. While some of the studies have limitations, explained in the cover sheet for Appendix G, they still provide a logical and parallel inference for potential general economic effects of fill minimization. That is, since some of the economic studies show that absolute fill restrictions increase mining costs due to additional material handling and use of different equipment, it can be inferred that minimizing fills will to some degree also affect mining costs.

The economics studies show a direct correlation between fill size and shifts in production due to increased mining costs. The Mining Technical Team Study projected, with fills limited to ephemeral streams, that 91% of reserves that were feasible for mining with larger fills could not be mined with smaller fills. The Hill & Associates sensitivity analysis projected reserve reductions of 22 and 45% as well as mining cost increases of around 8 and 14%, when all fills were restricted to 250- and 75-acre watersheds, respectively. The Hill & Associates studies generally concluded that smaller fills necessitate less complete extraction but more rapid depletion of the surface minable reserve base with different equipment types and a shift to underground coal production. The shift to underground production does not generally involve extraction of coal rendered unminable by surface mining fill restrictions.

For the same reason that the EIS supports case-by-case determination of fill number, size, and location for MTM/VF proposals, the actual mining cost increases and reserve reductions for any given mineral property could vary from these ranges. However, these studies clearly confirm the

intuitive relationships among inexpensive excess spoil disposal, mining costs, minable reserve reductions and mining viability.

Where mitigation presents significant costs to the applicant, the economic effect will likely be similar, but possibly less pronounced, to the results of the absolute fill restriction studies, inasmuch as mining methods that reduce the amount of excess spoil (and consequently reduce the size of fills and the amount of mitigation) will be selected. The effects on individual MTM/VF projects may be less pronounced than the study results because of the following:

- Projects may result in fills larger than the restrictions analyzed
- Site-specific costs, such as the following, may differ from the generalized study assumptions:
  - Varying combinations of equipment may be used
  - Material handling or haulage may be markedly different.

Mining methods resulting in smaller fills can cost more than mining methods supported by larger fills. As described above, this occurs due to a lower coal recovery per volume of overburden removed as smaller equipment types are utilized. Also, resource recovery at operations with smaller fills may be less complete than operations necessitating larger fills. This effect occurs when portions of coal seams that were economically minable by larger equipment cannot be mined (and may never be extracted) by operations using smaller surface equipment or underground equipment.

Mining decisions are also strongly influenced by market demand for particular coal quality. Many mines rely on blending the products of different surface mines or a combination of surface and underground coal to conform with supply contracts for particular coal quality. Also, transportation and coal preparation costs associated with smaller and underground mines are sometimes related to the proximity of larger mines with this existing infrastructure. If the infrastructure is not available, a new, smaller mine may not be practical. Therefore, the types and qualities of coal reserves available in various seams, transportation, and coal cleaning facilities may determine mining viability.

The alternatives proposed in this EIS also include other actions that could increase costs of MTM/VF application preparation and operation. The alternatives propose actions that would increase data collection and analysis costs to the applicant as well as application scrutiny and intra-agency coordination costs to the agency. These costs are discussed below.

3. Economic Consequences of the No Action Alternative

a. Government Efficiency and Coordinated Decision Making

Under the No Action Alternative, the SMCRA agency permit application review process and decision typically start and conclude prior to decisions by the COE and state CWA Section 401 certification. Therefore, the SMCRA review and surface mine design is finalized without early input from COE experts on protecting aquatic values within waters of the U.S., or by state experts on protecting water quality. This type of input at the conclusion of the process often requires modification of the issued SMCRA permit and/or re-design of the mine to accommodate the decision of the COE. This occurrence can add substantially to the time and resources already expended by

the applicant in fulfilling added SMCRA and NPDES reviews. In Virginia and West Virginia, the SMCRA and CWA Section 402 authority rest within the same governmental department and coordination regarding water quality protection in these states would continue.

The COE begins its CWA Section 404 review only after issuance of the SMCRA permit under the No Action Alternative. Because the surface mining operation has been designed to reflect comprehensive SMCRA review, there is pressure on the COE to work within the existing design so as to not significantly alter the mine plan--unless egregious adverse environmental effects would occur. However, there could likely be instances under the No Action alternative where SMCRA-approved projects would require redesign and reprocessing due to COE reviews. This causes increased permitting costs for the applicant and additional SMCRA agency resources to process modifications, revisions, or amendment of previously-issued permits.

b. Data Collection and Analysis

The No Action Alternative could result in increased costs to applicants as the new NWP 21 requirements are implemented. Increased stream characteristic information, impact projections, and demonstrations that impacts to waters of the United States have been avoided and minimized to the maximum extent practicable, and that compensatory mitigation is offered to offset unavoidable aquatic impacts will add field work, laboratory analysis, engineering computations, and likely more elaborate project designs. In the COE Draft Nationwide Permits Programmatic EIS (July 2001), the COE estimated that the cost to the applicant for CWA Section 404 permit is approximately $12,500 higher for an IP than for a NWP [2001 COE DEIS, Table D.4.2-4]. If the level of permitting remains constant in the No Action alternative, the overall increased cost to applicants would range from $1.6 to $1.9 million per year. There was recently an increase of permit applications for renewal of NWP 21 projects following renewal of NWPs in January 2001. These applications occurred for MTM/VF operations not yet initiated since their earlier authorizations expired in February 2003. Thus, the projected costs to applicants may initially be greater until the permit renewals are processed.

c. Consistent Definitions

Without common application of regulatory terms regarding streams [Chapter II.C., Action 2], there is the potential for less effective environmental protection and confusing regulatory responses to citizen concerns. This alternative could ultimately result in increased costs to the public and the regulatory agencies in the form of litigation.

The No Action Alternative is also likely to be more costly to the regulated community due to increased permitting costs associated with resolving conflicting requirements, time delays associated with obtaining the necessary permits to legally conduct mining activities, and potential litigation costs. These delays could occur, for example, when a project is planned in areas where stream characteristics are at issue. Costs of obtaining additional field data to resolve the issues could also accrue.

d. Mitigation

Action 10 is common to Alternatives 1, 2, and 3 and proposes to assure compensatory mitigation through coordination of SMCRA and CWA bonding and inspection. Mitigation under the No Action and action alternatives are discussed in Chapter II.D.6. The No Action Alternative provides no coordination regarding who monitors implementation of mitigation requirements and how mitigation projects are bonded and insured to assure successful completion. Under the No Action Alternative, any disturbances that might occur within the SMCRA permit boundaries would be inspected and bonded by the SMCRA regulatory agency to assure completion of required activities. SMCRA also requires the applicant/permittee to maintain liability insurance during the life of the permit and bond liability period in order to assure that anyone who might be harmed by the proposed activities has a viable opportunity to be made whole through civil court action.

CWA mitigation actions that may be required off-site (beyond the SMCRA permit boundaries) are under the regulatory control of the COE. The COE can, on a case-by-case basis, require performance bonding for mitigation activities. However, COE has no authority to require that permittee or contractors performing such mitigation activities have liability insurance coverage. Under Section 401 of the CWA some states, such as West Virginia, have established mitigation authorities to offset impacts to waters of the state. The COE considers these mitigation plans when evaluating mitigation proposals to satisfy requirements under CWA Section 404.

Since there are no defined, established procedures between COE and SMCRA authorities for coordinating on-site and off-site mitigation requirements such as bonding and inspection, there are both inefficiencies and risk in the current system. The risk is that in maintaining separate, uncoordinated systems, some aspects of a mitigation project may not be completed as required. The inefficiencies are present as the current system now requires separate permitting, separate monitoring/inspection, and separate bonds for what is essentially a single project (reclamation/mitigation). The environment may be impacted should any aspect of a mitigation project not occur. Duplication of permitting, inspection and bonding requirements result in increased costs to both the taxpayer (duplicate permitting and inspection staffs) and to the applicant (duplicate permitting and bonding costs).

e. Flooding

Flooding can adversely impact people, property, public transportation, and utilities. Flooding exacts considerable costs to individuals, insurance companies, as well as local, state and Federal governments. The causes of flooding may be a combination of the rainfall event and the man made alterations to land use, topography, ground cover, and stream channels. Human alterations to the landscape can also prevent or minimize flooding impacts [Chapter III.G]. Technical studies for this EIS indicate that peak runoff will typically increase during and shortly after mining on most sites. This may not be true of all mine sites and reclaimed sites may reduce peak flows compared to pre-mining conditions [Appendix H]. Alternatives 1, 2, and 3 contain an action to develop guidelines for calculating peak discharges for design precipitation events and evaluating flood risk [Chapter II.C.10]. In addition, the guidelines would recommend engineering techniques useful in minimizing the risk of flooding [Action 16].

With regards to the No Action Alternative, the study findings generally support a conclusion that downstream flooding potential is not significantly increased by existing mining practices so long as approved drainage control plans are properly applied [Appendix H]. However, variability in the

results suggests that this assumption cannot be universally applied, and that only site-specific quantitative modeling can determine whether potential for flooding is present for a given mine plan. Absent selection of an action alternative, permit reviews would continue to be evaluated in differing fashion from state to state by SMCRA agencies and COE Districts.

West Virginia currently uses the Surface Water Runoff Analysis (SWROA) guidelines, developed jointly with the COE and OSM [http://www.dep.state.wv.us/docs/28surfacewater.doc]. Kentucky advises permitting staff on general considerations for flooding potential assessments through a policy memo. The COE Huntington District evaluates flooding potential for each applicant based on a 100-year storm, while SMCRA evaluations may use a 25-year storm for some designs and 100-year storms for others. The COE Louisville District reported that no flooding evaluations occurred as part of their NWP 21 reviews. Application of these flooding analyses imposes increased analytical costs to applicants and administrative costs of review to the regulators. Mitigation measures as part of the mine plan result in added costs to the mining companies. The cost-benefit of these analyses should likely exceed the necessity of repairing flood damage absent the measures.

Recent flooding in West Virginia during 2001 and 2002, and the types of flooding analyses described above, resulted in the West Virginia Governor commissioning a study and OSM conducting oversight. Recommendations from OSM reviews could bring consistency to SMCRA programs under the No Action Alternative. However, the No Action Alternative would not necessarily resolve the differing approaches to flooding potential reviews by OSM and the COE. If quantitative analyses continued to be omitted in some states under the No Action Alternative, the risk would continue that some mine plans with increased potential for downstream flooding would be overlooked during the permit review process. If contributions to flooding from surface coal mining occur, flooding recovery costs could be imposed on operators, residents, state, local, or Federal governments.

4. Economic Consequences Common to the No Action and Alternatives 1, 2, and 3

a. Fill Minimization

The alternatives analyzed as part of this EIS, including the No Action Alternative, include the requirement for avoidance and fill minimization. This EIS does not provide a detailed discussion or quantified costs about compliance with the current CWA or future SMCRA fill minimization performance standards. This type of analysis is not required because the purpose of this draft EIS does not include evaluation of the costs of meeting fill minimization. Those requirements were subject to public scrutiny during the administrative process at the time the CWA Section 404(b)(1) regulations were promulgated.

Costs of compliance are not a factor in enforcement of SMCRA or the CWA that can override environmental protection standards set by law. An applicant may find that costs of compliance with the SMCRA and CWA performance standards are prohibitive to profitable mining of some coal deposits. Decisions as to whether company can internalize costs for avoidance and minimization are part of the many factors considered in making a business decision as to mining viability that should occur prior to application. However it is the purpose of this EIS to generally inform the

public and decision makers of the consequences of implementing measures for fill minimization on the economy.

Implementation of any quantified fill minimization evaluation methods under the action alternatives would increase the informational reporting requirements for permit applicants on sites that generate excess spoil. Overall review periods and amount of corrective correspondence between applicants and reviewing agencies would increase. This would have the effect of increasing mine permitting costs due to the greater level of effort required in application preparation.

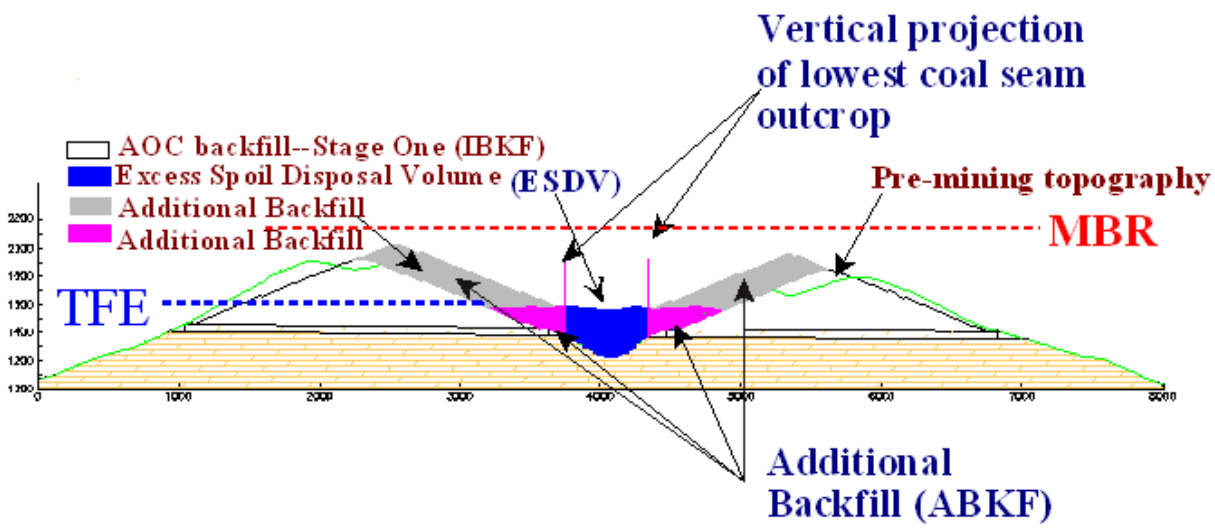
In some instances an operator may have to expand the permit area for upland disposal alternatives with consequent increased transportation costs and attendant costs for purchase or rights of access. Fill minimization may increase operational costs to the mining operator because spoil that must be returned to the mine site has higher handling costs than the current practice of end-dump valley fill construction. In many cases, backfilling on the mined-out area is performed by the same end-dumping techniques as excess spoil placement in durable rock fills. However, unlike durable rock fill construction, backfilling may increase haulage costs, which may be more expensive because of distance, or because loaded trucks must haul uphill (more maintenance costs to engines, brakes, suspension, greater fuel costs, haulage vehicles require replacement sooner, etc.) to back stack to higher elevations to minimize the amount of excess spoil. Backfilling in some areas may necessitate extra handling (grading and compaction costs) to assure stability. This can greatly increase material handling costs for the operator.

While not a direct comparison, and somewhat dated, the regulatory analysis by OSM for the permanent program regulations indicated that placing spoil in lifts versus end-dumping to build valley fills added 17 cents/ton to the cost of mining coal in central Appalachia [p. 98, Table 27, "Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977, Final Regulatory Analysis" OSM-RA-1 March 1979]. This cost would be a portion of other expenses to an operator that affect the cost per ton to mine.

The following case study exemplifies the impacts of minimizing fills by applying WVDEP's AOC+ policy. A proposed surface mine will create 65 million cubic yards (mcy) of mine spoil. Initial analysis indicates that 38 mcy of spoil will be returned to the mined out area and 27 mcy placed in adjacent valley as in excess spoil fills. After applying the iterative fill minimization analysis required by AOC+, more than 26 of the 27 mcy of excess spoil could be returned to the mining area, therefore minimizing the volume of spoil needed to be placed in excess spoil fills. [Figure IV.I-1]

By applying AOC+, 1690 feet less of valley fill length (than in the original mine plan) were avoided. Although the results of AOC+ are site specific, the overall effect of reducing the amount of excess spoil, the resultant size of the excess spoil fill, and direct impacts to streams may be greatly lessened when compared to the past fills before 1999 for mountaintop removal or large area mines. Similar minimization analyses would be developed and applied to contour mining. Illustrations of the results of AOC+ for the case study mine site are shown in Figures IV.I.-2 and 3.

Figure IV.I-1
AOC+ Results in Additional Spoil Returned to the Mined Area and Not in Streams



(Source: WVDEP AOC Guidance Document, 2000).

Figure IV.I-2
Illustration of General Results of AOC+ on Length of Stream Impact

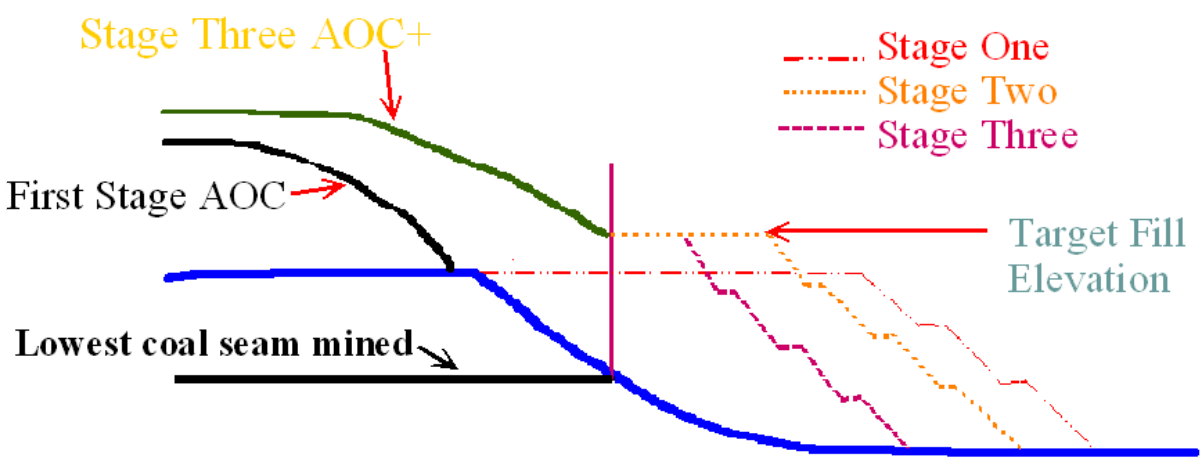
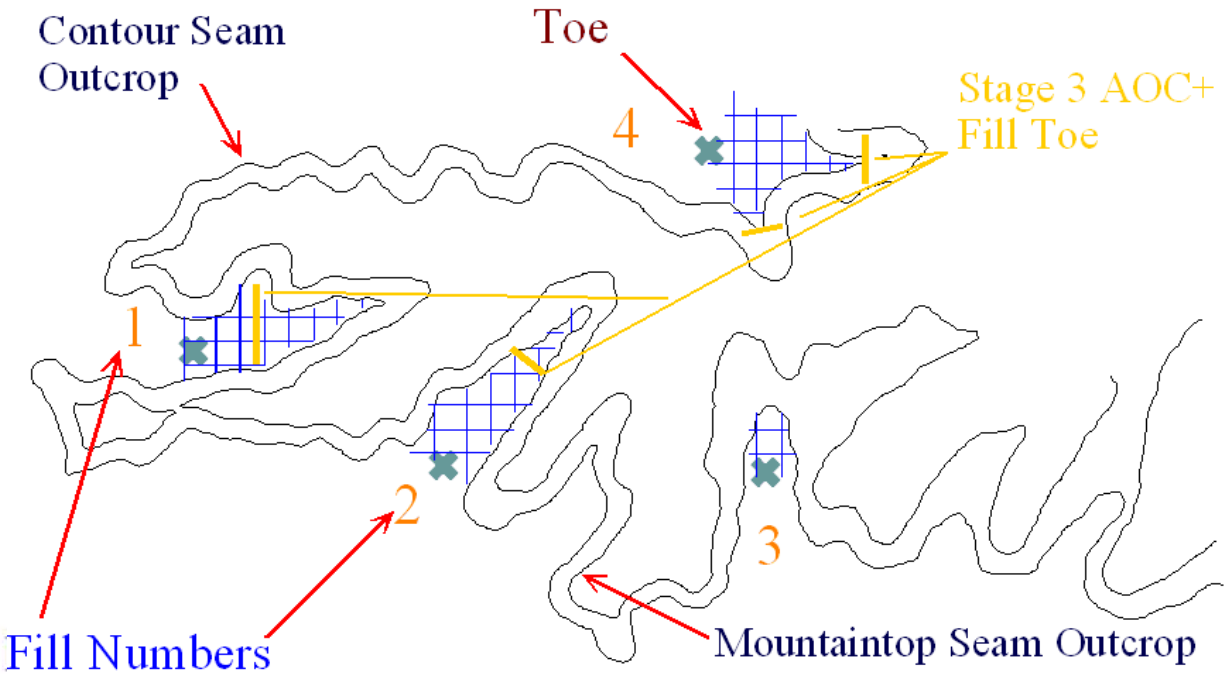


Figure IV.I-3
Illustration of Original Fill Toe Location (At Teal Colored "Xs"); and After AOC + Process (At Gold Lines)



Fill minimization costs for the operator under the example above would be dependent upon the additional logistics and haulage costs. The operator may have initially assumed that the 27 mcy could be hauled a short distance and end-dumped into a fill at relatively low costs. Upon applying AOC+, the operator must now haul 26 of the 27 mcy to the backfill area for grading and reclamation. If this additional hauling and handling adds $0.50-1.00/cubic yard, the operator must absorb $13-26 million additional operating costs from profit margins, if possible. While these increased costs will undoubtably reduce mitigation costs from affecting about 1700 feet of less stream reaches, some operations will likely become infeasible due to reduced return on investment. The only other alternative to mining the coal reserve and avoiding/minimizing valley fills may be to conduct contour mining and auger/highwall mining, consequently reducing reserve recovery considerably.

b. Data Collection and Analysis

The requirement to conduct stream functional assessments to determine size, number and location of valley fills, as well as the aquatic resource impacts and mitigation, will require additional biologists and ecologists in COE Districts under all alternatives, including the No Action Alternative. The data must be reviewed relative to extent of waters of the U.S., the completeness of the alternatives analysis, and the scoring of the biological, chemical, and physical conditions of the stream segments planned to be affected or analyzed as alternatives. These types of analyses are central to determining compliance the CWA Section 404(b)(1) Guidelines and setting adequate mitigation levels. The COE must evaluate the same type of data for adequacy of the proposed mitigation projects, to establish baseline stream characteristics, and review the stream

improvements. The COE must also perform site visits to determine if the projects are in compliance with permit conditions.

c. Mitigation

Under all alternatives, including the No Action Alternative, reclamation and mitigation practices are required by the CWA Section 404 program to restore stream habitat and aquatic functions impacted by MTM/VF through on-site reclamation and on-site and off-site mitigation [Chapter II.C.6]. These practices may include stream construction or enhancement, the construction of other aquatic systems, such as wetlands, and the restoration or enhancement of riparian habitat to compensate for the loss of aquatic functions. Preservation of high quality streams through creation of conservation easements or land trusts and the payment of in lieu mitigation fees for stream protection and restoration measure would also be considered. The costs for in-kind mitigation and in-lieu fee agreements may be considerable but are not presented in detail here. Presenting costs for complying with the COE regulations is not required, inasmuch as the purpose of this NEPA analysis is not to present alternatives to mitigation requirements.

Both on-site and off-site mitigation are likely necessary to insure that only minimal individual and cumulative impacts occur under all of the alternatives considered, including the No Action Alternative. The utilization of a stream assessment protocol provides a more accurate characterization of the loss of aquatic functions and the ability to more accurately predict the opportunity to restore aquatic functions loss at the reclamation or mitigation site. The protocol will also play a substantial role in identifying high quality streams, which may be avoided to reduce the impacts and associated mitigation costs.

Actions associated with Alternatives 1, 2, and 3 would require that a data collection program be implemented as part of utilizing a stream assessment protocol and a water quality and mitigation monitoring program [Chapter II.C.]. A more complete evaluation of the aquatic resources would occur before impacts to headwater streams would be allowed. The data and protocol would also be useful in designing future mitigation projects. There are many aspects regarding impacts of headwater streams and possible mitigation efforts for functions lost that can be better addressed through additional data collection. These actions would provide a venue to achieve this goal. Costs associated with the data collection were previously discussed in Chapter IV.I.3.b and 4.b. While mitigation costs occur under all alternatives considered, the costs to an operator are increased over mitigation costs required by the COE and/or the states prior to 1999.

A case example of alternative analysis and mitigation considerations was provided in Chapter IV.B.1.e. In the example, the Louisville COE District assisted a coal company in evaluating intermittent and ephemeral stream reaches for construction of valley fills and sediment ponds (with sediment transport channels intervening). Through use of the functional stream assessment protocol, the applicant was able to completely avoid intermittent streams, reducing 4,694 feet of originally planned stream impacts from 3 valley fills to a re-designed mine plan with only one fill in 950 feet of an ephemeral stream segment. In addition to decreasing linear feet of stream impacted, this re-design also avoided higher quality streams. The applicant satisfied this mitigation, in part, with on-site, in-kind restoration of the sediment transport channel between the fill and pond. The plan change reduced the mitigation costs from an original assessment of $300,000 to a $128,000 in lieu fee arrangement under the new plan.

Using only the COE case study as an estimate of cost per stream length impacted, mitigating the 724 miles of stream impacts from the Fill Inventory would assess in lieu fees over $516 billion. To avoid these costs carries other costs of material handling. The case-specific decision to construct fills or haul spoil will be integral to a mining financial plan.

d. Deforestation

Through efforts by states, the OSM forestry initiative, and other technology transfer and regulatory incentive methods, landowners and the regulated community are becoming increasingly more apt to implement forestry post-mining land uses and on-the-ground results are meeting with some success. Recent research shows that forestry post-mining land use is less expensive than typical grassland reclamation. Mine sites in Virginia indicate regrading costs for reforestation were reduced by $200-500/acre (Burger and Zipper, 2002). Research by Dr. Donald Graves at the University of Kentucky shows that, when compared to typical grading costs for establishing a hay land/pasture land use, an estimated $1,650-2,640/acre in reduced grading costs occurs when the research recommendations for forestry are followed (personal communication, 2003).

In Virginia, the majority of recorded post-mining land uses proposed on coal mine sites are forestry (VADMLR, 2002). A recent study of the proposed post-mining land uses on current mountaintop mine sites in West Virginia revealed that 68% of the sites were to be reclaimed to forestry-related land uses [Appendix G; (Yuill, 2002)]. There is not complete certainty that these reforestation efforts will resolve all the problems inhibiting the successful establishment of forest communities on reclaimed mine sites. However, recent research indicates quality forest communities equaling or exceeding growth rates existing prior to mining can be successfully and economically established on these mined sites. Improvements in the ability to re-establish a forest community on reclaimed mines sites comprised of highly-marketable species equal or exceed growth rates prior to mining.

As the number of years to re-establish forest decreases, economic benefits for the permittee, the landowner, and society in general are realized. The need of our nation for products derived from the forests (such as housing, paper products, furniture, etc.) places certain demands on the forest resource. This demand would be met more effectively through improvements in reclamation proposed in the action alternatives [Chapter II.C.8, Action 15]. Landowners will benefit as high quality forest follows mining. This provides greater opportunity to derive economic gain from the property, should the landowner choose to implement forestry post-mining land uses.

Timely re-establishment of quality forest communities on undisturbed natural sites or reclaimed mine sites do not prevent terrestrial impacts of deforestation described in Chapter III.F. But, with implementation of the latest research recommendations, long-term environmental effects are minimized and economic benefits of greater forest yields could be realized. Without an OSM effort to develop a BMP manual for the state-of-the-science in terrestrial reclamation, as described in Action 13, the rate of embrace of effective techniques may be slowed.

5. Economic Consequences Common to Alternatives 1, 2, and 3

a. Government Efficiency and Coordinated Decision Making

The basic and common tenets of surface coal mining regulatory programs (e.g., CWA Sections 401, 402 and 404, SMCRA, ESA, FWCA, CAA, NEPA, and other related state and Federal programs) are environmental protection and enhancement. State and Federal agencies responsible for implementing these programs strive to manage their respective programs to effectively accomplish the environmental protection goals, while minimizing duplication with other programs and avoiding the wasteful expenditure of human resources and public funds.

Three alternative approaches are proposed in this EIS to enhance the coordination among the state and Federal agencies in order to make each program more efficient and effective in minimizing the adverse environmental effects from mountaintop mining and valley fill construction. Only limited coordination among the various state and Federal agencies would occur with selection of the No Action Alternative. That is, a consecutive, rather than concurrent, MTM/VF application review process would likely continue without implementing actions described in Alternatives 1, 2 and 3.

Alternative 1 suggests that the COE make an initial determination of the size, number, and location of valley fills. Alternative 2 proposes a coordinated decision process among the COE and SMCRA regulatory authority to determine the size, number, and location of valley fills. Alternative 3 envisions the SMCRA regulatory authority initially determining the size, number, and location of valley fills. Increased coordination and determinations relative to siting valley fills carry administrative costs for the regulatory agencies as well as data collection, analysis, and application development costs for the mining industry.

Pertinent information regarding the SMCRA agencies and COE District Offices within the EIS study area follow. These data are relevant to regulatory and administrative costs under all alternatives.

Table IV.I-1
Comparison of SMCRA Agency and COE District Permitting Programs

State	Staff [1,2]	Payroll (millions)	New Surface Permits [3] (2001)	Other 2001 Permitting Actions [4]	Permit Acreage New/Other [4] (1,000s)
KY DSMRE	88	$3.0	58	234	13.2/31.1
TN OSM	11	$.9	3	38	1.1/0.6[6]
VA DMLR	22	$1.0	23	597	7.7/3.9
WV DEP	86	$2.4	30	314	10.2/0.8
SMCRA TOTALS	**207**	**$7.3**	**117**	**1145**	**35.8/33.1**
COE Huntington	9.6[5]	$0.57[5]	80 to 100		N/A
COE Louisville	3.0	$0.21	~35		N/A
COE Norfolk	1.3	$0.10	6 to 12		N/A
COE Nashville	0.9	$0.07	<5		N/A
COE TOTALS	**14.8**	**$0.95**	**126 to 152**		**N/A**

[1] SMCRA Agency staff working on permits of any type (surface, underground, preparation plant, etc.)
[2] COE District staff represent those staff working on NWP 21 authorizations and Individual Permits
[3] New permits issued for surface mining; does include all applications received.
[4] "Other" represents surface mining permitting actions involving renewals, modifications (revisions and incidental boundary revision); does not include underground mines and preparation plants.
[5] Does not reflect plans to hire two additional staff for coal mining-related work (~$115K/year)
[6] Includes acres from incidental permit revisions but not revisions

The staff organizational structure and budget represents those currently administering the permitting process under the No Action Alternative. To effectively administer the new procedures and reviews required by the revised NWP 21 for coal mining activities (i.e., case-by-case reviews of avoidance, minimization, and mitigation proposals for all unavoidable impacts to waters of the U.S.), additional COE staff would likely be required. For instance, the COE Huntington District anticipates hiring two additional people to process coal mining-related CWA Section 404 permits. The current workload is approximately 200 new permits per year with more than 1,000 other coal mining revisions typical in the EIS study region. To conduct the necessary fill minimization and flooding reviews reflected in proposed actions in this EIS, the estimated cost for additional engineers is $2+ million.

These staffing issues are closely related to actions described in other sections of this chapter, however they are generalized here because the level of staffing is critical to successful coordinated decision making and government efficiency. If any regulatory agency involved does not have adequate resources to provide thorough environmental compliance reviews of MTM/VF proposals,

the impact on other agency reviews and approvals affects the entire permitting process and project implementation. The design of a project with sufficient agency input, when properly inspected and enforced, has direct relevance to the quality of environmental protection and enhancement results on the ground.

As outlined below, Alternative 1 will result in the highest administrative cost to the state and Federal governments; Alternative 3, the lowest administrative cost; and Alternative 2, intermediate costs with a mix of Federal and state engineers performing reviews. Alternative 2 is more practical and realistic, since there are likely to be mining project applications that must be reviewed as IPs, and the COE would require engineers to complete both IPs and NWP processing.

b. Consistent Definitions

Action 2 is proposed for implementation under Alternatives 1, 2, and 3 [Chapter II.C.2]. Terms and stream characteristics with particular significance in the regulatory programs would be consistently applied through guidance, policy, or codified under common definitions through rule-making for CWA and SMCRA. Acceptable field methods and protocols for identifying streams and stream characteristics would be developed for the CWA and SMCRA programs. The Federal and state regulatory authorities propose to jointly prepare technical guidance to facilitate implementation of the use of these defined terms and delineation protocols by both the regulatory agency and the regulated community.

Implementation of Action 2 should result in impacts that are essentially the opposite of those outlined in the No Action Alternative. Less conflict and confusion over defined stream characteristics would result in better and more consistent environmental protections, lower costs to the industry and the ability to make business decisions prior to project application, and less likelihood of litigation-related costs to the local citizens, the regulatory programs, and the regulated community.

c. Data Collection and Analysis

The 2001 COE NWP EIS may understate anticipated applicant costs for NWP 21 submissions based on a more current and thorough consideration of the scope and effect of these requirements on MTM/VF proposals. While no detailed cost estimates are required or available for this EIS, the COE estimates are likely to be low by at least an order of magnitude. For example, some coal industry members asserted that the EPA biological/chemical monitoring stream protocol implemented in 2000 and 2001 in Appalachian steep-slope coal producing states would increase permitting costs by several hundred thousand dollars for larger permit applications due to the cost of additional benthic sampling and identification, testing for additional chemical species, and synthesis and analysis of data. This EPA stream protocol contains some of the components of the COE functional stream assessment protocol, however other data collection and analysis are required. Therefore, if performed by the applicant, the COE protocol may be more expensive than the 2000 EPA stream protocol.

The state or Federal permitting agencies would require additional staff with engineering expertise to conduct reviews of the upland alternatives/fill minimization analysis. This is particularly true of the COE in the No Action Alternative or Alternative 1, when COE reviews govern those permits

processed as IPs. The COE does not currently have staff with mining engineering background in the District regulatory branches. The CWA Section 404 minimization and alternative analyses involve a knowledge of mine planning theory and practice, as well as operational feasibility to determine if all practicable alternatives have been considered. While SMCRA agencies have these types of qualified staff on hand, the added analyses and review may exceed existing permitting staff capacity due to the large workload from permitting actions currently processed.

Discussions with a WVDEP engineer and permitting manager provided an estimate that fill minimization, through application of AOC+, adds 20% to the total time necessary for an engineer to properly analyze permits for fill minimization [personal communication, 2002]. WVDEP has around 14 engineers on staff. Assuming that all engineers might have to perform AOC+ reviews, three additional engineers (~$100-150K) would be required. This estimate may be liberal, because all engineers may not be involved in AOC+ reviews (i.e., they may specialize and, therefore, some segment of the WVDEP engineers review stability, ponds, hydrology/hydraulics, roads, etc.) and, with time, reviews could become more routine. Both applicants and state reviewers would become more familiar with the process, applications would improve, and review time eventually reduce. However, this estimate may also be too conservative, in that every permit with fills--whether contour mining or mountaintop removal-- will require some sort of more detailed fill minimization review and increase the overall average increased review time above 20%. Applying a 20% additional review time estimate to other states in the study area: Virginia DMLR will require at least one full-time staff and $45-60K in additional funding; OSM's Knoxville Field Office, one half-time staff and $38K additional funding; Kentucky DSMRE 3.5 full time staff and $120-200K in additional funding. Thus, an additional $3-400K in combined state revenues, federal grants, and federal salaries is the minimum estimated need for implementing this more detailed analysis of fill minimization under Alternatives 2 and 3.

COE increased staffing costs would be commensurate with the number of engineers that would be required to process the approximately 200 new surface mining applications and another 1000 permit revisions (e.g., modifications, incidental boundary revisions), renewals, transfers, mid-term reviews and other permit processing activities--many involving valley fills. The Federal government typically pays an experienced engineer, on average, ~50% more than state salaries/benefits. Under Alternative 1, the COE would need as many or more engineers as the state to review, comment, address revisions, and approve around 2-300 mountaintop mining proposals per year. Estimating 25-35 additional federal engineers to do COE AOC, flooding and other reviews translates into around $1.8-2.5M (20 experienced GS-12 engineers at ~$75K = ~$1500K; 15 GS-11 at ~$63K = ~$945K). Under Alternative 2, the COE would need fewer engineers to: 1) do more limited reviews of the state SMCRA authorities alternative/fill minimization analyses in the SMCRA permit, for NWP 21 permitting actions; and, 2) to perform more rigorous evaluations for those applications requiring IP processing. Under Alternative 3, the COE would also need some level of engineers for the approval of state reviews needed to issue NWP 21 authorizations.

c.1. Economic Consequences of Data Collection and Analysis Unique to Alternative 1

Alternative 1 anticipates that the COE would take the lead role in determining the size, number and location of valley fills placed in waters of the U.S. and set the level of compensatory mitigation. All surface coal mines proposing to place fills in waters of the U.S. would initially be processed as IPs. This would be a significant change from the current COE permit process. The COE would

determine whether a project EIS or a EA/ FONSI would be required. Processing permits in this manner would result in a much more rigorous review by the COE.

Alternative 1 involves the COE performing the necessary avoidance, fill minimization, and mitigation assessment of MTM/VF proposals. The COE and EPA affirmed that use of the WVDEP AOC+ policy satisfies the requisite alternative analysis required by the CWA 404 (b)(1) Guidelines. For consistent application across the various COE Districts with jurisdiction over CWA Section 404 coal mining activities in Appalachia, the COE would either evaluate the adequacy of existing state SMCRA authorities AOC policies or, develop other procedures for applicants in Virginia, Kentucky and Tennessee to demonstrate that projects have satisfied the CWA Section 404 (b)(1) Guidelines.

It is certain that the regulatory costs of Alternative 1 would increase for the COE, in that the IP review and preparation of the NEPA compliance documents will require more staff. The COE estimated in its Draft NWP Programmatic EIS that processing permits under the NWPs cost an average of $389 compared to $1492 for processing IPs [2001 COE DEIS, Table D.4.2-1]. Based on the level of scrutiny required to satisfy the CWA 404(b)(1) Guidelines, evidenced through the EIS development process and interim permitting coordination in West Virginia, the COE estimates appear low. However, assuming that the number of permits processed will remain constant with the No Action Alternative (200 permits per year in the EIS study area), and the costs remain consistent with the COE 2001 estimate cited, the COE will experience an increase in administrative cost ranging from $400,000 for IPs, to over $2,000,000 per year for IPs and other revisions under this alternative.

Because of the additional staff resources needed to perform chemistry, biology, ecology, mining, and civil engineering reviews of impact predictions, alternatives, fill minimization, flooding, and mitigation analysis, these estimates may be understated by factors ranging from 10 to 20 times COE 2001NWP EIS figures. The NEPA compliance and public interest reviews result in greater COE processing costs due to the larger documents, more expansive detailed information, and additional opportunities for public participation and wider review and comment potential from local, state, and Federal agencies and organizations. An IP also provides for more EPA and FWS oversight and elevation of issues through the CWA 404(q) process that is not afforded in the NWP 21 process.

Conversely, state SMCRA agency costs for permit processing could decrease based on the reviews performed by the COE. The level of review by the states on the effects to the aquatic ecosystem should be reduced if they rely on the COE assessments. A number of other hydrologic assessments required by SMCRA could assist the COE in NEPA compliance. For instance, the state SMCRA and water quality reviewers would focus more on drainage and sediment control structure design, potential effects on water supplies, maintaining the hydrologic balance, PHC/CHIAs. The SMCRA review of terrestrial, post-mining land use, blasting, roads, embankment and impoundment stability would complement the COE NEPA compliance. The MOA and FOP envisioned under this alternative would detail the sequence and the inter-relation of permit review components by each agency.

An applicant for a CWA Section 404 permit would provide more information to process IPs, increasing costs to the applicant. The data and analysis costs are similar to the description above in the No Action Alternative. To help reduce processing time, the applicant may choose to prepare draft EAs and/or EISs for an IP which would add greater costs. These documents must address not

only the site-specific impacts of the mining proposal, but cumulative impacts of the project as well. EISs undergo multiple iterations of widespread distribution and review, comment, and possibly litigation. These steps could add considerable time to application processing and can affect the cash flow and investment positions of a mining company due to unpredictable time frames for mining operation commencement due to issue resolution, project re-design, litigation, etc.

Despite the increased costs to an applicant, there should also be some offsetting efficiency for the applicant due to better coordination between regulatory agencies. Multiple revisions by the applicant should not be required, as agencies would coordinate review comments and deficiency letters so the applicant could address all issues at the same time. Joint discussions between agencies, and between the agencies and the applicant, should better define compliance targets for the applicant with improved applications for both public and regulatory reviewers.

c.2. Economic Consequences of Data Collection and Analysis Unique to Alternative 2

Alternative 2 anticipates OSM (in TN) or the appropriate state SMCRA agency maximizing coordination and joint processing the SMCRA and CWA Section 404 permits. Unlike Alternative 1, in which the applicant applies separately to SMCRA and CWA agencies, a joint application would be developed containing the permitting requirements for both agencies. Like Alternative 1, more rigorous information and analysis would be required of the applicant; surface mines will be designed in consideration of both programs; and the SMCRA agency and COE would review the information to minimize duplication and maximize the use of each entity's respective expertise and regulatory focus. Also, like Alternative 1, the agencies would enter into an MOA to outline the coordination process and develop FOPs to expand on specific parts of the coordination roles and responsibilities for certain portions of the mining proposals. This coordination would greatly aid the applicant in understanding requirements, clearly address compliance criteria, and provide more comprehensive and comprehensible applications to meet CWA and SMCRA standards as well as better inform public and other interested stakeholders. The consequences of this integrated review alternative would include increased environmental protection, reduced processing times and costs to the permit applicant, and reduced administrative costs.

The COE would make case-by-case decisions on the type of permit process and level of NEPA analysis for MTM/VF projects. Therefore, the consequences of Alternative 2 are dependent on the number of permits requiring IP versus NWP processing. To the extent that a certain percent of permits must undergo IP review, the economic consequences would be similar to those described for Alternative 1. Similarly, those permits authorized under NWP would have consequences similar to those described below in Alternative 3.

Another important element of the coordinated decision making process in Alternative 2 is the revision of SMCRA regulatory program provisions [Actions 3 and 7]. The revision would provide for data collection and minimization/alternative analysis more consistent with the requirements of the CWA Section 404(b)(1) Guidelines.

Increased cost for COE reviews would be less than those costs described in Alternative 1, because all applications would not be initially reviewed as IPs. The SMCRA agencies would take on a greater role in fill minimization and alternative analysis, as well as considering on-site mitigation in SMCRA permit decisions. The COE review for approving NWPs should require less rigorous

evaluation, in order to determine that all CWA considerations were made in the state review. COE reliance on SMCRA reviews should decrease processing costs considerably. SMCRA agencies, on the other hand, would likely require additional biologists, hydrologists, ecologists, and engineers to conduct the necessary analyses. The relative increased staffing costs to the states would be proportionately less than the increases for the COE. States have a full compliment of disciplines in their larger permit review organizations than the COE does and economies of scale should apply. State program costs are generally less than Federal program costs. Table IV.A-1 shows that state program staff levels are more than sixteen time COE permitting staff for coal mining, while the state costs are only eight times the COE payroll and benefits. Thus, from a staffing increase perspective, Alternative 2 presents potential cost savings over Alternative 1.

c.3. Economic Consequences of Data Collection and Analysis Unique to Alternative 3

Alternative 3 anticipates that the SMCRA regulatory authority would promulgate provisions for fill minimization and alternative analysis more consistent with CWA Section 404 requirements and take the lead processing and conducting the initial reviews. The COE and the SMCRA agency would work together to develop a joint application containing SMCRA and CWA Section 404 permitting requirements.

Increased SMCRA staff would be required to conduct the initial reviews due to additional biological/ecological stream chemistry aquatic data, and more mine planning, hydrology, and hydraulic engineering evaluations. The consequences of this action are similar to the No Action Alternative in some ways because the COE would begin processing most permits as NWP 21. The administrative cost of this alternative will be similar to the No Action Alternative, but lower than either Alternatives 1 or 2. COE staffing increases are likely, but less than Alternative 2 and markedly less than Alternative 1. State staffing increases would be similar to Alternative 2 but slightly higher because additional minimization and alternatives analysis review, done by the COE in Alternative 2, would be borne by the state in Alternative 3. Administrative costs to the Federal agencies have the potential to be lowest in Alternative 3 if states ultimately can use the SPGP authority and the majority of permits qualify for the SPGP due to adequately minimized unavoidable aquatic impacts. There are no financial incentives for the states to gain CWA Section 404 authority, and the state costs for this authority have not been factored into this analysis. However, costs associated with SMCRA related to avoidance, minimization, and alternative analysis may be covered by 50% OSM regulatory grants.

The information and analysis submitted by the permit applicant will increase permitting costs, but less than Alternative 1 or 2 if most permits are eligible for NWP 21. The absence of NEPA compliance and a streamlined COE review should reduce applicant costs, although it is unlikely that every permit could qualify for NWP 21.

d. Mitigation

If Action 10 is implemented under Alternatives 1, 2, and 3 as proposed, the agencies would, as a part of the MOU developed under each of the action alternatives (and if necessary with revision of existing SMCRA or CWA regulation, policy, or procedures), clearly define and commit to writing the roles and responsibilities for permitting, monitoring/inspection, and bonding of mitigation projects. This would provide the agencies with the opportunity to coordinate these activities in order

to increase certainty that all mitigation requirements are being implemented and minimize identified inefficiencies associated with duplicate systems. By incorporating all mitigation construction plans/specifications, time lines, and success criteria into each issued permit, inspectors would have all the information needed to ensure the mitigation projects are properly completed. This would also serve to minimize costs to both the taxpayer and the applicant.

e. Flooding

Alternatives 1, 2, and 3 share a common action specifically designed to more effectively evaluate flooding risk during SMCRA or CWA permitting. The action proposes joint development of guidelines for appropriate flood risk evaluations by the COE, OSM, and state SMCRA authorities. The guidelines would discuss suitability of different modeling algorithms for various situations, the proper rainfall frequency/duration and other mining site condition (runoff curve numbers and other values, like time of concentration, travel times, roughness coefficients, etc.) assumptions for assessing flood potential.

The effect of a modeling requirement on the permitting process would be variable depending on the degree of complexity of the modeling, but would generally increase costs to the applicant and permit review agencies. The effects on individual permit applications would depend on the size of the application, complexity of the mining plan, and number of modeling points required for the assessment. Large, complicated permits would require more effort than small, simple mine plans. Except in cases where multiple valleys below a mine would drain to a single pond, the number of modeling runs required for each permit would depend on the number of stream valleys downstream of the proposed mine.

Requirements for site-specific runoff modeling would increase the costs of permitting to mining companies for each permit application; and to regulatory agencies for individual project reviews and for cumulative impact analysis of multiple operations in a cumulative impact area. Coal operators would see increased costs from permitting consultant fees or internal engineering staff reflecting the greater engineering effort required to prepare a permit application. Regulatory agencies would likely need additional skilled staff, either as preparers of the CHIA models, or for model reviews when submitted by permit applicants. The dollar value of such changes cannot be predicted without established modeling guidelines.

The quantitative analysis of the potential for flooding caused by a MTM/VF operation will affect the cost of permit preparation, review, mining and reclamation, and inspection. This effect would be variable depending on the degree of complexity of the mining and reclamation plans. Large, complicated permits would require more effort and cost than small, simple mines. The cost of permit modeling may not be as substantial as implementing the on-the-ground controls to assure mining does not increase flooding risk above what existed pre-mining. For the coal company preparing the permit, this analysis may include the consideration of various mining plans and surface water runoff control scenarios. These scenarios could consider water detention structures, drainage patterns, maximum disturbed areas, soil and overburden handling, reclamation configuration, and ground cover. Each scenario will have its associated costs for construction and implementation during mining and reclamation. Recent application reviews by WVDEP using the SWROA have resulted in considerable application revisions that limit the amount of disturbance open at one time

in particular watersheds, hydraulic control changes to channels, and different runoff routing through a watershed–with attendant costs for construction.

The review by regulatory authorities of quantitative analyses of flooding potential for an application would require additional effort, including additional staff who have had adequate training to evaluate the surface water control plan for each permit. The regulatory authority may also require additional staff and training to inspect the surface water control structures at each permitted operation during mining and reclamation to assure plans are effectively carried out and certified by engineers.

While there are additional costs for application preparation, review, implementation, and inspection, the potential for the mine site to contribute to offsite impacts due to flooding would be decreased by this action. This consequence of better protecting the public and the environment meets the intent of the existing regulatory requirements. Additionally, quantitative analysis may result in denial of permits that are allowed under the No Action Alternative. Denial of or a decision not to proceed with a project proposal could depend on the selected flooding risk threshold, increasing overall costs to the mining industry from unfulfilled plans and potentially placing some reserves off-limits to mining.

Regardless of the actual flood risks, there can be real or perceived consequences when persons down stream of an actual or potential surface mine site believe that surface mining increases their risks from flooding. The perceived flood risk can affect land uses and property values by reducing the willingness to live on and make improvements to properties in such areas. This perceived risk problem can be exacerbated when the residents lack confidence in the veracity and forthrightness of mining operators. Recent actions by mining companies following flood events have ranged from generous temporary housing and re-establishment of residents in new or repaired homes to denial of any liability for flooding results. Both reactions may be warranted based on the findings of runoff studies for this EIS. That is, flooding consequences are very site-specific to conditions above and in any stream valley.

f. Deforestation

Alternatives 1, 2, and 3 share an action for development of BMPs for selecting appropriate growth media, reclamation techniques, revegetation species, and success measurement techniques for accomplishing post-mining land uses involving trees [Chapter II.C.8.; Action 13].

The implementation of this BMP could have economic impacts for the landowner and the regulated community. For instance, some of the BMPs may encourage maximizing forest product recovery. Forest product uses may increase revenues to the landowner, if the market, including transportation costs, provides a viable price for the product. Implementing organic utilization practices in the BMP manual could add cost to the mining operation, when compared to the existing practices for disposal of organic materials remaining following logging. These costs would vary, with windrowing and organic “islands” likely being less costly than mulching.

The implementation of BMPs related to revegetation success standards could have economic impacts for the regulatory agency and possibly for the regulated community as well. Regulatory agency costs would be incurred in applying any BMP guidance in the field (employee training,

additional field measurements or tests to determine success, etc.) If any new BMP guidance resulted in a mine site not meeting revegetation success standards, the extended bond liability period and any supplemental revegetation activities needed to meet the revegetation standard could increase costs. However, if research recommendations for establishing a suitable growth medium for trees are followed, the decreased costs of reclamation may offset any increase cost to the regulated community.

Another proposal common to the action alternatives is the requirement, if established by Congress, to require reclamation with trees [Action 14]. The Congressional authority envisioned under this action would require reclamation with trees where trees were the pre-mining condition, unless environmental improvement could be demonstrated by alternative post-mining land uses. From a cumulative impact standpoint, this alternative would result in more widespread use of trees and may be more effective at assuring the values associated with a forest community are re-established following mining. However, this action could also result in increased or decreased costs to the regulated community as operators (who would not otherwise have planted trees) may now be required to use reforestation reclamation and successfully plant trees with a healthy/successful yield. Improving property value by establishing a land use other than forest may not be an option for the landowner under this alternative. The applicant may be unable to demonstrate higher environmental value for non-forestry land uses to receive a variance from such a statutory mandate for reforestation of the property. Administratively, such Congressional action, if implemented, could result in an increase in takings claims. The mere filing of, much less success in, takings claims could have substantial impact to state and federal governments. Litigation, settlement, and judgement costs regarding property rights, could present liability to agencies.

g. Air Quality

The action alternatives propose a common action that would result in BMPs for controlling fugitive dust and blasting fumes or additional regulatory requirements, as appropriate, to minimize these types of adverse air quality effects [Chapter II.C.9; Action 15]. Use of BMPs does not necessarily carry additional costs, depending on the site-specific circumstances. However, requirements to provide dust suppression technology or minimize blasting fumes would likely add considerable costs to monitor and implement additional controls.

J. RECREATION

Tourists are drawn to the visual, cultural, and natural amenities found throughout the study area. Resident and non-resident tourists travel to various outdoor recreational sites throughout the study area for camping, hiking, fishing, swimming, canoeing, hunting, boating, and sight seeing, biking, skiing, off-highway vehicle use, golf, running and festivals. According to Canaan Valley Institute, the Mid-Atlantic Highlands Region offers diverse, economically significant opportunities for recreation and tourism, including hiking, birding, camping, swimming, canoeing, white water rafting, skiing, and other outdoor recreational activities, generating $26 million/year in direct revenue. In addition, hunting and fishing license sales bring in more than $88 million/year to state economies in the Appalachian region. (CVI, 2002) The EIS study area is a part of the Mid-Atlantic Highlands Region. A discussion of Outdoor Recreation and Tourism can be found in Chapter III.T.

Tourism and travel businesses include private and public lands and facilities, such as, campgrounds, hotels, motels, restaurants, gift shops, service stations, amusements, other recreation facilities, and undeveloped real estate. Within the study area in West Virginia alone, there are approximately 15 state parks and forests, in addition to 10 designated wildlife management areas. The Mid-Atlantic Highlands already contains many public lands that are attractive to visitors, but 75% of the forested lands remain in the private sector (CVI, 2002).

Public land needs and demands are very heavily tied to recreation development in the region. There are certainly localized demands for public lands for uses such as schools, community parks, and other public facility developments (West Virginia State Comprehensive Outdoor Recreation Plan, 1997). However, the acreage requirements for most of this development are minimal, and will be linked to existing community locations in most cases. A compilation of the major demands for public lands in the region identified by various federal and state agencies shows significant differences between counties in the region in the need/demand for hunting and fishing, water recreation, and special needs recreation areas–facilities that generally require significant areas. Counties that have a high demand/need for one or more of these activity areas are Kanawha, Lincoln, Logan, Raleigh and Wayne Counties [WVDNR Capital Improvements Plan 1998; WVU Land Use Assessment 2001].

In addition to public lands being available in the study area for recreational activities, private lands are used for recreation by members of the public. It is assumed that, although some of these private lands were affected by MTM/VF operations, the region contains similar lands which are available for recreational experiences outside the locale of a particular MTM/VF operation. Further it is recognized that recreation opportunities related and unrelated to mining are changing in the study area and region. Another limitation to public recreational use of private lands is the fact that landowners who previously tolerated unrestricted access to their land have reacted to increased use and liability concerns by restricting access to private lands.

1. Consequences Common to the No Action and Action Alternatives

Tourists, residents and landowners enjoy the natural environment for outdoor recreational activities including camping, hiking, fishing, swimming, canoeing, hunting, boating, and sight seeing, biking, off-highway vehicle use, golf and festivals. Dramatic topography and generally good air quality

combine to create spectacular vistas. Many of the vistas can be seen from highways back country byways and public lands. Other vistas because of their remote locations can only be seen from the air, private lands or a nearby mountain crest. Tourists are also drawn to the study area for outdoor oriented recreation at the available sites. Available recreational facilities in and around the study area include state parks, national forests, state and federal fish and wildlife management areas as well as privately owned lands open to the public. Most of the lands in the study area are privately-owned and managed.

Public parks, forests, management areas and privately owned lands open to the public, in and around the study area have a growing number and diversity of visitors seeking recreation and access to the visual, cultural and natural amenities of the region. Projections show that the number of visitors to outdoor recreational facilities in the study area and surrounding vicinity will continue to grow, particularly for camping sight seeing, hiking, biking, and off-road vehicle use.

The effects of mining on recreation tend to be localized and depend on a variety of factors. These factors include the size and type of the mine, the mine setting, the recreation activities occurring in the area, the experiences derived from these activities and opportunities for similar activities in other nearby areas. Examples of the types of effects that coal mining development and operations could have on recreation include the following:

- Loss of recreational resources that might lead to displacement of the activity to alternative areas or loss of ability to engage in the activity;
- Modification of recreation settings leading to changes in recreation experiences and types of recreation facilities available due to project related activities or the presence of project related facilities;
- Reduced feelings of solitude and remoteness due to the introduction of visual, sound or other sensory effects from project related activities or the presence of project related facilities that could conflict with recreation use; and
- Changed access to the area, which could open the area to some uses but close it to others. For example mine developments may reduce opportunities for non-motorized outdoor activities while increasing opportunities for motorized recreation.

Residents and visitors to the study area use the natural environment for a range of activities including the harvesting of non-traditional forest products and subsistence gardening. Non-traditional forest products include sassafras, ginseng, goldenseal, mayapple, slippery elm and other botanical products which can be harvested in the Southern Appalachia region. In the Appalachia region specifically, the harvesting of non-traditional forest products contributes to the local economy. Some wild gathering or subsistence gardening locations may be affected by MTM/VF operations. Surface mining operations, by nature, do not allow for concurrent alternate land uses. Another contribution to the decline in lands in the study area being used for wild gathering or gardening is the fact that private landowners have increasingly begun to close off these lands to the public for safety and security reasons. The inherent decline in the ability to engage in gardening or wild gathering by the general public is likely to continue under all the alternatives. However, through improved co-ordination and analysis envisioned under all the alternatives, this decrease in opportunities could lead to alternative areas being created or set aside to be enjoyed as “commons.”

Habitat changes will occur in the study area. Some of the changes will involve a shift from a forest-dominated landscape to a fragmented landscape with, in some instances, considerably more grassland habitat. MTM/VF operations contribute to fragmentation of a forested landscape. The shift from a forest dominated landscape to grasslands and forest edges can lead to a shift in the plant and animal populations from forest to grassland or forest-edge species. The indirect effect of a shift in the plant community is an increase in game species such as whitetail deer and turkey due to an increase in grasslands and the diversification of habitats. The continued habitat changes in the study area are likely to occur with or without MTM/VF operations. A proposed action common to all the alternatives is designed to facilitate reforestation efforts. The direct impacts of MTM/VF operations, in this regard, to recreation dependent upon a forest dominated landscape may be temporary, if the post-mining land use is to restore the pre-mining forest habitat or permanent, if the site is developed for a post mining land use other than forest. The consequences to recreation of such land use shifts under all alternatives are changes in the type of outdoor recreation experiences available. For example, bird-watching for forest interior species will likely be replaced by bird-watching for grassland or edge species while hunting (wild turkey) opportunities could increase. Consequently, the forest recreation activities affected by fragmentation whether due to MTM/VF or other causes would change the recreation experiences available.

Areas that offer more primitive recreation opportunities could decrease because of the vulnerability to mining dominating the local setting by the elimination of the wild land character due to noise, traffic, dust or other mining related condition. Also, development pressures from activities other than MTM/VF operations to primitive settings could decrease the availability of primitive recreational opportunities in the study area. The direct impacts of MTM/VF operations, in this regard, to recreation dependent upon a remote and wild landscape may be temporary, if the post-mining land use is to restore the pre-mining habitat, or permanent, if the site is developed for a post mining land use other than what existed pre-mining. Consequences to recreation of such mining conditions are changes in the type of outdoor recreation experiences available in the local setting of the mine site or those seeking primitive recreation opportunities to look elsewhere in the study area for such recreational opportunities. To the extent MTM/VF would affect the primitive character of recreation in the study area the magnitude of such effects would be the same under all the alternatives.

Lands in the study area provide diverse recreational experiences. All mining permits, including MTM/VF operations include a designated post-mining land use. In some instances, a mine site will be reclaimed to a public recreational use, or after reclamation, be converted by the landowner to a recreational use. An example of where mine sites may be reclaimed to a designated post-mining land use as recreational facility is the development and maintenance of the mine site as a public golf course. An example of a change in recreational use after reclamation is when trails are developed on a former mine site for hiking, biking, camping or other use open to the public. The diversification of recreational opportunities in the study area is likely to be the same under all alternatives.

Added access to local settings in the study area could increase the accessibility of existing recreational opportunities or provide a way to previously isolated land that could be developed for recreation. The building and/or improvement of roads to and on MTM/VF operations have the effect of making previously inaccessible areas attractive for use or development. For example improved public roads and/or new mining roads increase the accessibility to new local settings for

off-highway vehicle use (some times with landowner permission and sometimes without). The increase in access to local settings within the study area is likely to continue an the consequences be similar under all alternatives.

The effects of MTM/VF operations on recreation would vary a great deal based upon the resource setting, the current recreation use of the area, the size and type of mine and opportunities for using alternative areas. Overall, under the alternatives it is anticipated that recreational opportunities in the study area will continue to change and diversify. In addition increased co-ordination in management of lands to be mined in the study area could improve overall recreation experiences at developed, undeveloped and new recreational sites.

A constant in recreational opportunities in and around the study area which will be unchanged under all alternatives is the existence of substantial public parks, forests, wildlife management areas or National Wild and Scenic Rivers. A discussion about these public lands is contained in Chapter III.T. Since these public lands in the study area and similar public lands around the study area are generally off limits to surface mining operations, they will remain available for a broad array of recreational opportunities from primitive to developed facilities (e.g. swimming pools). Mitigation envisioned in all the alternatives could be employed to conserve, preserve or otherwise add lands available for public recreational uses.

Areas adjacent to the study area provide opportunities for additional recreational experiences. These alternative locations have similar visual and natural resources as found in the study area and provide alternate sites for outdoor recreation in the event mining diminishes or displaces sites in the study area currently in use for recreational experiences. The consequences of the No Action and action alternatives are similar and cannot be distinguished from each other.

K. ENVIRONMENTAL JUSTICE

Under the auspices of Presidential Executive Order 12898, "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations (February 11, 1994)," federal agencies are required to evaluate the impacts of any federal action (e.g., COE 404 permit or OSM permit in Tennessee) to determine if the proposed action will disproportionately affect a minority, low-income, or culturally distinct community or population. This Executive Order, commonly referred to as the environmental justice (EJ) order, is intended to see that no person or group of people should shoulder a disproportionate share of the negative environmental impacts resulting from the execution of this country's domestic and foreign policy programs, and to ensure that those impacted have a meaningful role in the decision-making process. Preparation of this EIS document is also considered to be a federal action subject to the requirements of an environmental justice review.

In implementing the EJ review in this document, each individual action was considered as to the potential impacts of the action and alternatives, including the No Action Alternative, on identified EJ populations. It should be emphasized however, that this executive order applies only to Federal actions. Permitting of an individual proposed mine application by a state agency, when a SMCRA program is delegated to a state, would not be subject to the requirements of EJ. Issuance of a COE individual CWA 404 permit or SMCRA permit in Tennessee would require an EJ review prior to issuance.

To the extent that low-income populations are prevalent in the coalfields, the impacts of mountaintop mining are felt disproportionately by these environmental justice populations. The most notable impacts to be felt by coalfield residents are the operational disturbances, particularly blasting. For example, blasting can be particularly problematic for low-income persons, because they tend to live in substandard or non-traditional housing and may utilize poorly constructed water wells as their drinking water source. As indicated in the blasting studies, such structures may be more vulnerable to damage by blasting vibrations lower than levels that would affect structures built to modern standards [Appendix G.]. However, SMCRA blasting regulations provide for lowering performance standards to account for these circumstances.

Confirming the presence of an environmental justice population is a site-specific exercise that can only be done once an operator submits an application for an individual federally-issued CWA or SMCRA permit. It should be noted that the decision to mine coal is based on a number of factors such as the geologic location of minable coal deposits. Thus, as a review of the mine feasibility evaluation and planning factors described in Chapter III.L. indicates, the ability to mine in a particular location is an economic one and there is no reason to believe the presence or absence of an environmental justice (or any other segment of the) population affects the decision to mine.

In the context of this EIS as a Federal action and compliance with the EJ requirements, the Federal agencies have focused attention on human health and environmental conditions in the communities that may be affected by mountaintop mining activities. Issues or impacts that may disproportionately impact low-income populations in the EIS area are identified as "significant" issues for purposes of NEPA in Chapter II.A. The public participation process associated with this EIS has been quite exhaustive, as described in Chapter I.D. With the preparation and completion

of this document and availability for review and comment by the public, the Federal action agencies have complied with the requirements of the EJ Executive Order.

As for individual mining activities that are proposed under either SMCRA and/or CWA regulatory authorities, residents and communities located near proposed mine sites may feel that efforts to make them aware of a proposed mine are insufficient; that they are not provided adequate opportunity to participate in the permit process; or that if aggrieved by a mining operation, the complaint process is too challenging and intimidating. However, both SMCRA and the CWA have established numerous opportunities to make the public aware of proposed mining and potential impacts to human health and the environment and to solicit input from interested parties. Notices are mailed to local officials, agencies, utilities, etc. when a mine is proposed. The proposed permit application is made available for review by the public at a place accessible to the public. SMCRA requires ads in the local newspaper weekly for four consecutive weeks advising the public of the proposed project, where and when the application is available for review, and where to send comments and/or request a public meeting on the proposed permit. Ads may again be placed in newspapers or other means of public notification when CWA permits are issued under Section 404 (fills) and Section 402 (effluent/basin discharges). An ad is placed in the local newspaper again before any blasting is to occur. Blasting notifications are mailed to everyone living within ½ mile of a mine site if blasting is proposed. If a NEPA document for a federal action is required, the public is advised of the preparation of the document in accordance with established NEPA regulations. The action agencies find that these notifications are more than adequate to notify the public of proposed mining, advise the public of potential impacts, solicit input from those potentially affected, and comply with the both the requirements and the spirit of the environmental justice executive order.

Although no statutory basis exists in either SMCRA or the CWA to base permitting decisions (i.e., approvals or denials) on EJ issues, proposed issuance of a federal permit requires the action agency to comply with the goals of the EJ executive order. Under the EO, an agency must: (1) focus federal agency attention on human health and environmental conditions in EJ communities, (2) foster non-discrimination in federal programs and actions that substantially affect these populations/ communities, and (3) give the EJ populations/communities greater participation opportunities and greater access to public information on matters of public health and the environment. Under NEPA, if disproportionate impacts on minority or low-income populations are identified, a proposed action is not precluded from going forward, nor does it compel a conclusion that the action is environmentally unsatisfactory. Rather, identification of such an effect should heighten agency attention to alternatives, mitigation measures, monitoring needs, and preferences expressed by the affected communities or populations (CEQ, 1997).

In December 1, 2000, the EPA Office of General Counsel stated in a memorandum regarding the EO on EJ: "...there are several CWA authorities under which EPA could address environmental justice issues in permitting." EPA Adminstrator Christie Whitman concurred and reinforced this statement in a memorandum dated August 9, 2001: "Environmental statutes provide many opportunities to address environmental risks and hazards in minority communities and/or low-income communities. Application of these existing statutory provisions is an important part of this agency's effort to prevent those communities from being subject to disproportionately high and adverse impacts, and environmental effects."

The federal action agencies comply with the requirements and the spirit of the EJ executive order both in the development of this EIS document and in the implementation of the federal programs to regulate mountaintop mining activities. The processes in place both for the development of this document and for the processing of permit applications by federal agencies provide the mechanisms to identify the concerns of the public, including EJ populations, and provide numerous opportunities for their participation in the decision-making process. As such, none of the alternatives include any new or revised process-related actions that are specifically directed at the identification and participation of EJ populations in the federal agency decision-making process.

Myth: All surface-mined land is reclaimed equal to or better than it was prior to mining.

Fact: The Appalachian Highlands are characterized by some of the best and most diverse forest habitats in the world. Current reclamation practices are unable to restore native mixed hardwood forests, but rather replace these ecosystems with fields of non-native grasses. These changes in habitat may significantly impact neotropical bird populations, native salamander populations and other sensitive species.
Source: Trial Lawyers for Public Justice

Fact: The "Surface Mining Control and Reclamation Act and the Clean Water Act do not require that sites forested prior to mining would be reforested as a part of the post mining reclamation requirements."
Source: US Environmental Protection Agency

Myth: Coal Companies do all they can to reduce the negative impact mountaintop mining has on the environment.

Fact: Reclamation is usually done late in the mining process for ease of operation. In order to reduce the size of valley fills and reduce reclamation costs, coal companies should reclaim the land contemporaneously with mining.
Source: Ohio Valley Environmental Coalition

Fact: Valley fills are built from the top down. If valley fills are constructed from the bottom up, they will shrink in size due to leveling and compaction.
Source: Ohio Valley Environmental Coalition

Fact: Slurry produced by coal mining contains dangerous heavy metals, including: Antimony, Beryllium, Cadmium, Chlorine, Chromium, Cobalt, Lead, Manganese, Nickel, Selenium, Arsenic and Mercury.
Source: US Geologic Survey

Fact: In the Appalachian Plateau, iron and manganese concentrations exceeded US Environmental Protection Agency drinking water guidelines in at least 40% of the wells, and about 70% of the wells near reclaimed surface coal mines.
Source: US Environmental Protection Agency

Myth: The coalfields of Kentucky and West Virginia need more flat land for development purposes.

Fact: Over 300,000 acres of West Virginia have received surface mine

Buffalo Creek

In the days preceding February 26, 1972, rain fell almost continuously, although experts later claimed this was typical for late winter weather in the area. Buffalo Mining officials, concerned about the condition of the highest dam, measured water levels every two hours the night of the twenty-fifth. Although a Pittston official in the area was alerted to the increasing danger, the residents of the hollow were not informed. The company sent away two deputy sheriffs, who had been dispatched to assist with potential evacuations. Despite the lack of warning from company officials, some residents sensed the danger and moved to higher ground.

Looking downstream near the former site of Dam No. 3

Just prior to 8:00 a.m. on February 26, heavy-equipment operator Denny Gibson discovered the water had risen to the crest of the impoundment and the dam was "real soggy." At 8:05 a.m., the dam collapsed. The water obliterated the other two impoundments and approximately 132 million gallons of black waste water rushed through the narrow Buffalo Creek hollow.

In a matter of minutes, 125 were dead, 1,100 injured, and over 4,000 left homeless.

One thousand cars and trucks were destroyed.

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POKING HOLES IN CHURCHILL'S CIVIL-LIBERTIES RECORD; THE DOWNSIDE OF BLOW JOBS; A SUBMISSION FOR GRAYDON CARTER'S IENGINE IDEA; B._P._-NOT-SO-JOLLY GREEN?; AND MORE

BODY:

One thing that can be said of Henry Porter's much-needed dissection of Tony Blair is "Better late than never" ("Blair's Big Brother Legacy," July). Porter does have the grace to admit that he, like almost all the British media, should have gotten onto this a long time ago. To this day it is incomprehensible to many of us how the British Parliament-which used to be the ultimate authority of government as well as the elected representatives of the people-allowed Blair to take the country into an illegal war with Iraq without even consulting with it, let alone putting the war to a vote. The situation was amply mirrored in the U.S. by George W. Bush and has been consistently documented by Vanity Fair. This sorry moment in English history was where Blair's crypto-Fascist arrogance first took hold. As we now know, and should have known then, taking his country to war had nothing to do with protecting the country's security and everything to do with surreptitiously mounting an assault on England's precious civil liberties. It is an embarrassment that a complacent majority was "out to lunch" while all this was happening. Porter, nevertheless, is to be commended for documenting with such clarity how it happened and continues to happen, still largely unchecked.

JOHN MANN
Cathedral City, California

WHILE READING HENRY PORTER'S article, I kept feeling a sense of dEj vu with our own political situation in the States. After I finished, I went online (to VanityFair.com) and read the e-mail exchange between Tony Blair and Porter. I was gobsmacked at just the prospect that the prime minister of England would participate in such a civilized e-mail exchange with anyone who was critical of his policies, let alone a member of the press. Can anyone in the U.S. truly imagine this scenario happening here?

Porter's article was superb in its illustration of the creeping, subtle, and cumulative ways in which civil liberties can be and have been abrogated in the U.K. Unfortunately, our loss of these same liberties here in the U.S. has not been so understated. While I am not convinced of a nefarious motive on Blair's or Labour's part (as opposed to our dear leader), it is clear that in the U.K., as in America, the occupant of the executive seat is indeed trying to accrue as much political power as he can.

However, the news is not all bad. Because we both are still functioning democracies, what good will these powers be to each of them one minute, hour, or day after they leave office? All it takes is an election to stop this slide. So remember, register and vote!
JENN CRAYTHORNE
Tampa, Florida

HENRY PORTER'S piece sounded rather like the righteous protest of the rich, who are insulated from the realities of daily life in inner-city Britain today.

With regard to his criticism of the new option which harassed members of the public have of an antisocial-behavior order (ASBO), clearly, Porter, who no doubt lives in a plush London neighborhood, has never had death threats made against him by a neighbor who has been asked to turn his music down (something that has happened to me).

And as for Neil Tennant, the wealthy Pet Shop Boy, who would take issue with the police's stopping him to check his ID card on the well-heeled King's Road in London, again, surely he would be a world away from being exposed to crime and terrorism.
CURRAN MATTHEWS
London, England

I FOUND Henry Porter's piece on Blair wonderfully revealing and devastating, but I thought his labeling of Winston Churchill as a guardian of civil liberties rather odd for several reasons.

Any reading of Churchill's actions against Italians in the aftermath of Italy's entering World War II-having them arrested and immediately interned-certainly does not put him on the side of civil liberties.

Additionally, historian D. A. N. Jones wrote that Churchill, during the Boer War (1899-1902), praised the white enemy for not arming the black population, which he referred to as "the Black Peril." And Howard Zinn points out in The Politics of History that while serving as home secretary Churchill accompanied the police as they burned the homes of suspected anarchists to the ground, which resulted in the deaths of the suspects. In the aftermath, Churchill wrote to the prime minister that he would have "to stiffen the administration of the Aliens Act a little."

It is not certain whether old Winnie would be spinning in his grave so much as applauding Blair's efforts to stifle free speech for the good of "national security."
EDWARD DAVID JUILLARD
Chicago, Illinois

ORAL HISTORY
I TAKE EXCEPTION to the statement by Christopher Hitchens that the blow job came into its own with Deep Throat in 1972 ("As American as Apple Pie," July).

In 1969, I picked up Joan Garrity, a former employee of my publishing company, in a taxi and gave her a lift to a job interview a few blocks away. I had phoned to tell her that I was going to "change her life." I told her I wanted her to write a book. "Don't you remember," she said, "we parted because I couldn't write a press release."

"I want you to write the way you talk," I said. Then I spoke the words that would trigger a gross of nearly $50 million worldwide: "I want you to make cocksucking respectable in America."

The book was titled The Sensuous Woman, and it remained on the best-seller lists in 1970 as a cloth-cover book for almost a year, selling more than 600,000 copies. The paperback edition has sold more than 10 million copies to date. With that single book we turned what had been considered a perversion into a normal sex act.

Deep Throat, which Mr. Hitchens wrongly credits with doing that, came two years later, when it was discovered at

the World theater and publicized by Al Goldstein in his Screw magazine.
LYLE STUART
President, Barricade Books
Fort Lee, New Jersey

EDITOR'S NOTE: Lyle Stuart, the controversial book publisher who famously feuded with Walter Winchell and Steve Wynn and who released several notorious books (including The Anarchist Cookbook, Naked Came the Stranger, and the aforementioned Sensuous Woman), died on June 24, 2006-a week after sending V.F. this letter. He was 83.

THE POET Philip Larkin wrote, "Sexual intercourse began in nineteen sixty-three." I must remark on the great tongue-in-cheek (pardon the pun) piece Christopher Hitchens has written about the blow job. As I approach the age of one of your outstanding contributors, Dominick Dunne, it is amazing to see what changes have taken place in America in these 80 years, especially in sexual attitudes. Ah, to live it all again!
MIRIAM CENTER
Savannah, Georgia

I TOOK THE PICTURE of Sue Lyon as Dolores in Lolita on page 52 of the July issue for my best friend Stanley Kubrick in 1960 in Sag Harbor, New York. I purchased the heart-shaped sunglasses for 39 cents at the five-and-dime store, which is still there. I ended up spending a week in Sag Harbor with Sue Lyon and her mother taking pictures for the movie. I devised all my ideas for the photographs from reading Nabokov's novel.

I did not get a blow job, but I did get screwed by not receiving a photography credit for use of my photo in Christopher Hitchens's article. However, I am grateful for the opportunity to set the record straight in my favorite magazine.
BERT STERN
Sag Harbor, New York

IF THERE IS a "resurgence" of fellatio, as purported in "As American as Apple Pie," the article would have redeemed itself by noting that oral sex among junior-high and high-school students is accepted by many as "O.K." and "no big deal" thanks to our former leader Bill Clinton, or by mentioning how disease is spreading among youngsters because they believe that there is no downside to this behavior. Are you so desperate to fill space that you indulge your enfant terrible by allowing prurient garbage to masquerade as information worthy of your publication? This article is the deal breaker, and we are canceling our subscription.
M. J. WARREN
New York, New York

CHRISTOPHER HITCHENS'S ARTICLE reminded me of those "succulent 60s." You had to work real hard to get blow jobs, but I remember mine well-even the bad ones.
FRED GURNER
New York, New York

A LOOK BACK TO THE FUTURE
AT THE END OF JULY'S Editor's Letter ("The Heart of a 21st-Century Machine"), Graydon Carter calls for the development of an "iEngine," as a replacement for the internal-combustion machine. In 1958 my father, Giovanni Savonuzzi-past director and designer of Cisitalia and Ghia, in Torino, Italy-came to the United States as chief engineer for turbine research at Chrysler Corporation. Over the next 10 years he developed the turbine-engine car, built it, and drove it around a block in New York City, fueled by ArpEge perfume and peanut oil. After he brought the car back home to Birmingham, Michigan, I used to love riding in it because of the stares-not only for its futuristic design, but also because of the hissing sound it made on "takeoff." In 1968 my father returned to Italy as director of research at Fiat, and he used to refer to the turbine car as a "vanity project" way ahead of its time. Might not that time be now?
ALBERTA SAVONUZZI

Upperville, Virginia

B.P.'S SHADES OF GREEN

WHEN I SAW British Petroleum C.E.O. Lord John Browne featured as an environmental hero in Vanity Fair's Green Issue (May), I was, as we say in East Tennessee, madder than a wet hornet.

Every American should be outraged by the V.F. photograph of Browne, the grotesque hypocrisy of B.P.'s "green" P.R. efforts, and the shocking gullibility of the press.

Two months before the V.F. issue hit the streets, a corroded B.P. pipeline on the North Slope of Alaska leaked more than 267,000 gallons of oil into the Alaskan tundra. The spill, the worst in the history of the Alaskan North Slope, was not discovered by B.P. leak-detection technology but by an employee who just happened to drive by and notice it.

This oil leak, in March, was not an isolated, unexpected incident. For years, B.P. has dragged its feet on even minimum requirements to maintain its pipelines. In 2002, B.P. was fined and ordered to install leak-detection systems when it was found to be lagging behind state mandates. In addition, in 1998, the company and its contractors were fined millions and placed on criminal probation for burying thousands of gallons of toxic materials in an Alaskan oil field, an illegal activity that came to light thanks to a whistle-blower. And yet, thanks to a nifty eco-friendly logo and what some have dubbed a "reformed sinner" P.R. campaign ("We know we've been bad to the environment, but now we're doing our small part to make things better"), there's the picture of Lord Browne in V.F., right alongside photos of real everyday heroes doing the little things that make a difference.

To me, the fact that Browne and B.P. are portrayed in this article as heroic and not villainous is a striking example of a troubling aspect of our culture: what you say is more important than what you do.

After a lifetime in politics, I'm certainly not naIve, but somewhere along the way, good old-fashioned accountability was compromised to an extent that I had never witnessed. How did we reach a point where a company making billions of dollars while Americans are gouged at the pumps, a company leaking precious American oil at a time when our country is desperately trying to reduce its dependence on foreign oil, is honored by the press?

Other aspects of B.P.'s style-over-substance campaign have played out in full view of the public. When the company rolled out its new, "sunburst" logo, in 2000, Browne himself was quoted as saying, "It's all about increasing sales, increasing margins." The company that realized there was money to be made in appearing environmentally friendly is the same company whose Texas City, Texas, refinery had more than three times as many toxic pollutants as the nation's second-most-polluting refinery, according to the E.P.A.

Whether you are young or old, live in a red state or blue state, I hope we can all agree that this whole scenario represents the worst of America in 2006-a huge company pollutes the earth while representing itself as an environmental hero, and a lazy press falls for the whole charade.

Back in England, Browne must be chuckling at how he has pulled this one over on the good old U.S.A. It's time the press and the public held him accountable for polluting our land and our values.

JIM HALL
President, Hall & Associates
Washington, D.C.

VANITY FAIR REPLIES: While the recent environmental accidents Mr. Hall cites are serious and harmful, they do not nullify the progress Lord Browne has made to push B.P. toward taking responsibility in the global-warming debate and adopting more environmentally conscious operations. Browne is not new to the environmental movement: he acknowledged global warming in 1997, the first representative of a big oil company to do so. Between the company's significant investments in solar power and renewable-energy technologies, and its goals to reduce CO2 emissions (which it has done ahead of schedule), there's no doubt that Browne is committed to environmental issues.

WHAT WE OWE IRAQ

I AM WRITING REGARDING two articles in the July issue, "Rumsfeld and the Generals" (by Michael Wolff) and "The War They Wanted, the Lies They Needed" (by Craig Unger). There are, I think, fewer and fewer people who still believe that the casus belli for the Iraq war was more than a paper-thin sham of rationalization and lies. If even half of what either side is saying is true, it is crystal clear by now that we attacked a sovereign nation for the wrong reasons. While I wholeheartedly appreciate every effort made by every journalist to present the truth to the public, and delight in phrases such as "Rummy ontogeny," I believe that these articles can only go so far. When we invaded Iraq we destroyed its government and much of its infrastructure, and now-no matter who lied and why-we owe it to the Iraqi people to put them back on their feet before withdrawing. This is the piece of the puzzle that very few that are against the war seem to understand. The medical, food, transportation, energy, and security foundations must all be reconstructed so that the Iraqi people can go on with their lives. This should be the highest priority of our nation, and a cause to which all of us should devote our efforts.

In the here and now, it seems that it would be a wonderful undertaking for magazines such as yours to begin talking about what the American people can do to help sort out the mess-be it through letters to Congress, food and clothing drives, fund-raising, anything. The sooner we align our efforts to rebuild Iraq, the sooner we can bring the troops home and focus our energies on more worthy initiatives.
DAVE KANTER
New York, New York

MOUNTAINS OF DENIAL

DON BLANKENSHIP'S response (Letters, July) to Michael Shnayerson's "The Rape of Appalachia" (May) is typical big-coal propaganda. He says the mining and production of coal don't lead to war, but there is an endless war being waged in these hills among the coal companies, the politicians who enable them, and the fine people of West Virginia who have found themselves in close proximity to the coal seams of Appalachia. Three million pounds of explosives are used against West Virginia's mountains every working day.

My friend lives less than a mile from Hobet-21, an unimaginably large coal mine that was once a lush, diversified forest. She can't drink her water or take showers without worrying about her exposure to chemicals.

This is the war being waged every day on the people of West Virginia. Please keep listening to the stories of the people who are continually rendered less important than this "inexpensive" energy source that Blankenship lauds. Like the "inexpensive" goods bought at Wal-Mart, cheap electricity comes at a great cost to the people of this state and to the country that is just beginning to realize the beautiful gem that is disappearing every day.
ELEANOR GOULD
Charleston, West Virginia

I AGREE with Don Blankenship that the world has a serious problem with excess oil consumption and that the war over what's left of it is, arguably, the most serious political and environmental issue facing the globe today. But Blankenship's notion that there is some sort of either-or decision-either prevent environmental damage or create jobs; either reduce greenhouse gases or eliminate poverty-is an example of the energy industry's classic "reasoning" that somehow we have to choose between social and economic justice and a livable planet.

In a world where we can virtually eradicate polio and put a man on the moon, surely we can apply some of that ingenuity to find new ways to heat our homes, generate jobs, and heal our sick without scarring our world. Visionary companies are already proving that there are ways to be environmentally responsible, create jobs, and make money at the same time. Pretending that environmental damage is a necessary evil-and not a deliberate choice-is disingenuous and an insult to the intelligence of Vanity Fair's readers.
LESLI BOLDT
Vancouver, British Columbia

SOMEONE SHOULD EDUCATE Don Blankenship about what makes up any list of the "necessities of life." Last time I looked, dry land would be toward the top of that list. It's something that will be in short supply as coal burning expedites the continued melting of the ice caps.
GREGG ARONOFF
Acton, Massachusetts

DON BLANKENSHIP says that people can be helped only by truths. Well, global warming is a truth. Yes, the problems he mentioned (aids, starvation, war, lack of clean water-something, I would like to point out, he is contributing to at an alarming rate) are catastrophic. I would never marginalize them by saying they are not; however, if we-or should I say Massey Energy?-continue to ignore global warming it will only exacerbate all these problems, along with causing mass global climate change. Blankenship, Massey Energy, and its money-hungry cronies are wrong to assert that global warming isn't real. The sad thing is they are only fooling themselves and taking us down in the process.
SARAH NUFFER
Queens, New York

REASONABLE DOUBT AT DUKE
THE SITUATION INVOLVING Duke's lacrosse team and the rape accusations was not, as Buzz Bissinger opines, the inexorable result of many wild nights and many deaf ears ("That Championship Scandal," July). There is a lot of under-age drinking and rowdy misbehavior at many colleges. No, what has happened at Duke is the result of a publicity-seeking local prosecutor in a re-election campaign loudly proclaiming their guilt to the TV cameras, despite having no reliable evidence against any of the lacrosse players. And of a university president who, by dodging his own responsibility for having failed to curb athlete partying, penalized the entire team by canceling the lacrosse season before even the most cursory investigation of the actual facts had taken place.
W. S. WHITING
Baltimore, Maryland

TRUTH OF THE CODE
WHILE THE DA VINCI CODE didn't shake one aspect of the foundation of Christianity ("The Da Vinci Clone," by Seth Mnookin, July) or its basic teachings about things such as integrity, money, and compassion, it did help shake my faith in the American judicial system. Any judge who fails to see the parallels between Dan Brown's and Lewis Perdue's books possibly lacks the perceptive skills necessary to being a judge in the first place.
RUTH HAMMER
Bronx, New York

DAN BROWN, with considerable help from his wife, Blythe, wrote a book that, under the safe guise of fiction, rehashed historical and religious data that have been around for centuries. I have an M.A. and a Ph.D. in English literature and semiotics; I am familiar with textual analysis, symbolism, cryptology, and art history. But it doesn't take scientific "plagiarism-detection software" or legalese to discern that the Browns did a cut-and-paste job. The "genius" behind the book was the incredible marketing campaign, which took an otherwise negligible novel and propelled it to stellar success. I empathize with authors such as Perdue who, unlike Brown and company, got ripped off because they didn't have sufficient funds to secure a solid legal defense.
ROMANA ROGOSHEWSKA
Montreal, Quebec

KING OF THE TRACK
AS SOMEONE who taught his five-year-old that the epitome of a sports car is the 1967 Shelby GT500 KR convertible, I was more than happy to come across Robert Levine's profile of muscle-car legend Carroll Shelby ("King of the Road," July).
But an error appeared in the first paragraph of an otherwise fine article. The Ford GT500 is not a hand-assembled, $150,000 sports car modeled on the GT40; that car is simply called the Ford GT. The Ford GT500 is based on the

current Mustang, like the Shelby Mustangs built in the 1960s.
JEFFREY MOSER
New York, New York

IT WAS RATHER DISAPPOINTING to see the article on the Shelby Mustang following hot on the heels of May's Green Issue. So one month you are all about saving the planet and the next you are writing an ode to a muscle car that's only about "performance," rather than energy efficiency. What gives? I guess you have to take back all those pats on the back you gave yourselves for boldly writing about environmental issues. Shame on you!
NICOLE BELL DAVIES
Toronto, Ontario

CARVILLE, BY GEORGE!
THE REFERENCE by James Wolcott to the short-lived Steven Soderbergh-George Clooney HBO series, K Street ("It's Not Easy Being George," July), brought to mind the time they were filming the series one afternoon in Washington, D.C. I was attending a reception and a woman friend came in breathless and said, "I just saw James Carville!" She was so thrilled at the sighting that it took a while for her to add, "And George Clooney was standing next to him." Only in Washington, D.C., would a woman notice James Carville before George Clooney.
DRUCELLA A. ANDERSEN
McLean, Virginia

Letters to the editor should be sent electronically with the writer's name, address, and daytime phone number to letters @vf.com. Letters to the editor will also be accepted via fax at 212-286-4324. All requests for back issues should be sent to subscriptions@vf.com. All other queries should be sent to vfmail@vf.com. The magazine reserves the right to edit submissions, which may be published or otherwise used in any medium. All submissions become the property of Vanity Fair.

POSTSCRIPT
In December 2000, contributing editor Edward Klein investigated why nuclear scientist Wen Ho Lee spent 278 days in solitary confinement without a trial ("The Hunting of Wen Ho Lee"). After China allegedly obtained plans for a U.S. nuclear warhead, Taiwanese-born Lee found himself the target of a spying probe as the government scrambled to explain security lapses at the Los Alamos laboratory, in New Mexico, where Lee worked. When news outlets got wind of the investigation, in 1999, a media frenzy erupted, and Lee was fired from his job. Then the F.B.I. made its discovery: Lee had downloaded weapons files from a Los Alamos server onto portable computer tapes. This colossal blunder was reason enough not only to indict the soft-spoken scientist on 59 counts but also to throw him in lockdown. Nine months later, when Lee's attorneys finally proved he wasn't a threat to national security, Lee was released, pleading guilty only to mishandling computer files (the other 58 counts were dropped). Klein's article left us wondering: Would Lee get vindication?

Lee did get payback-but it took a while. After his arrest, Lee's attorneys sued the government for violating the Privacy Act. The claim sought the names of the anonymous officials who had leaked the scientist's personal information to reporters from five news organizations (ABC, the Associated Press, the Los Angeles Times, The New York Times, and The Washington Post). In June 2006, after litigating for five years, the government and media outlets agreed to pay Lee a combined $1.65 million. Although Lee hadn't filed against the news organizations, they joined the settlement in order to prevent disclosing their reporters' sources. "Dr. Lee is very pleased by the results," says Brian Sun, Lee's attorney, "and hopes that this resolution can send out a strong message that this type of unlawful (leaking) conduct by government officials should not be condoned."

But a major question from Klein's article still remains: Why did Lee download the computer files? Take it straight from the source: in his book, My Country Versus Me, which was published in 2002, Lee claims he copied the material simply to protect it from loss.

MORE FROM THE V.F. MAILBAG
"It was delicately written, I know ... "

(We are speaking, of course, of that Christopher Hitchens piece.)

"But ... "

(Here it comes.)

"I just can't picture my hero writing about stuff like that. I just can't."

And yet, Dorothy, he did.

Although "As American as Apple Pie" was a "witty essay," according to Michael C. Browning, of Palm Beach Gardens, Florida, Hitchens was nevertheless wrong to trace the origins of "blow job" to a contraction of "below job." In fact-after sweeping wide to ruminate on the Victorian sex memoir My Secret Life, with specific discussion of such French terms as gamahuche and faire la minette-Browning concludes that he "would not be surprised if 'blow job' were purely modern and American."

As for Norman R. Newman of Indianapolis, Indiana, he "can't wait for (Hitchens's) sequel on cunnilingus. The principles of balanced and responsible journalism demand (it)." (Whoa. Can we say "cunnilingus" in this magazine? Well, if we can say "gamahuche" ...)

So how many of you caught the "typo" on the Sandra Bullock cover? Only two? That doesn't say much for V.F.'s 6.2 million other readers, does it? "Guys, use spell check," wrote one of The Two. "You misspelled 'Girl' on the cover of the July issue" ("Hollywood's Least Scandalous Newlywed Unleashes Her Inner Grrl"). Damn, we could have sworn we glanced at the cover copy after we typed it up. Heads wll rll.

"I am 60 years old and I have never read Vanity Fair in my life," writes Dr. Paul Wood, from Hamilton, New Zealand. "I bought (your Green Issue) out of curiosity, expecting it to contain shallow, poorly informed 'infotainment journalism.' Wow, was I in for a re-education session about a glossy magazine. I found in-depth articles from informed (and) courageous people." (And that in an issue without a Q&A by George Wayne!)

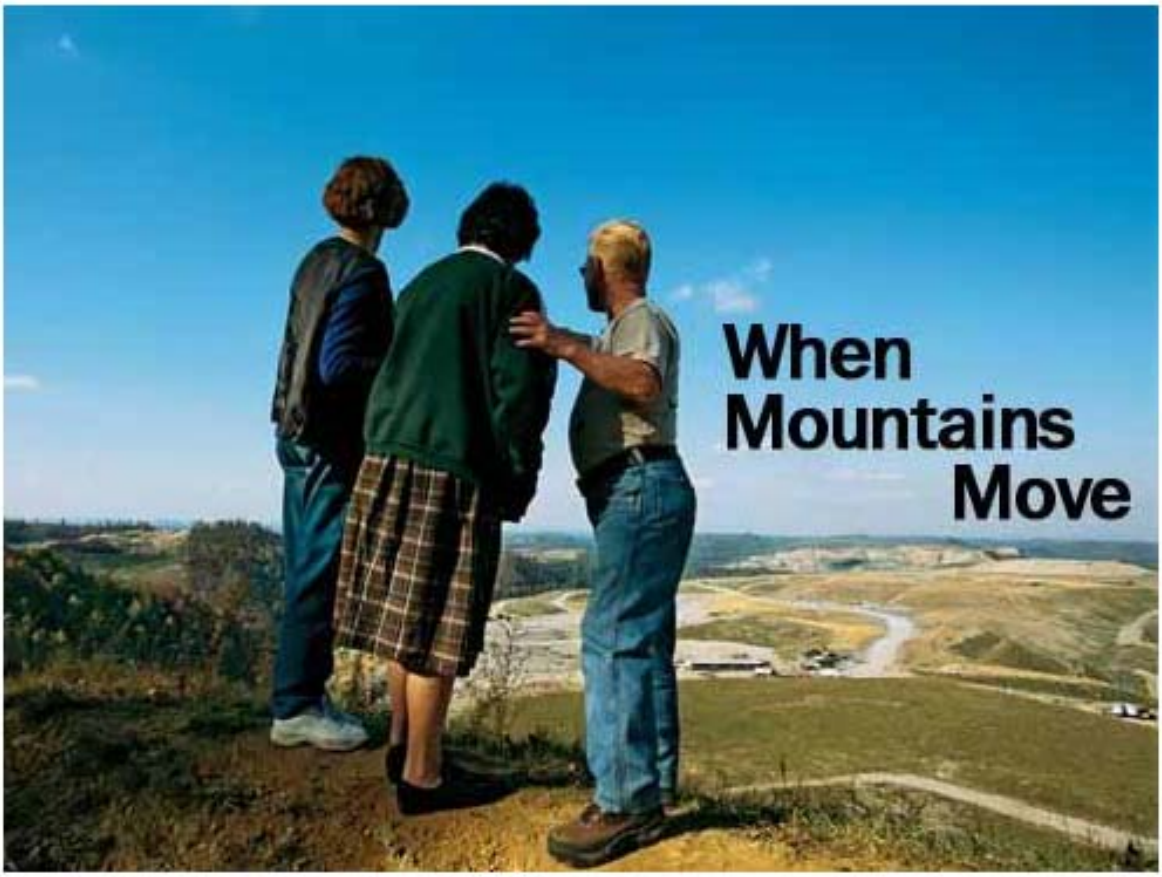
The monthly Proust Questionnaire is meant to entertain and to reveal and assess the intellectual reflexes of various well-known people. Never have we regarded it as a vehicle for soliciting organ donations. And yet one kind soul, after having read Art Buchwald's answers in July, has been in touch about offering Buchwald a kidney. Truly.

"Bravo!" to Graydon Carter for his July editor's letter calling on us to wake up and be accountable for our consumption as Americans, says Erin Fray, of Point Reyes Station, California. Very nice. But Fray's effusiveness caught the Mailbag off guard. That reference to "the sleeping dragon that lies within (Graydon)" only winged us, but we had considerably more trouble imagining him as "a blade of grass stand(ing) up," particularly one (it all too quickly transpired) possessed of a "lion's roar." Frankly, if we thought there was any chance we'd be working for roaring dragon-lion creatures who try to pass themselves off as blades of grass, we'd never have bothered to fill out all those forms at Human Resources.

GRAPHIC: DANIEL BEREHULAK
BLAIR'S green zone
London police surround Parliament Square during a demonstration for the Right to Protest, August 1, 2005. Five protesters were arrested.
BOTTOM, BY MIKE FIALA
MILLION-DOLLAR MAN
Last June, the U.S. government and several media outlets agreed to pay Wen Ho Lee (seen here in 2000) $1.65 million

to settle his privacy lawsuit.
RETHINKING THE CAR
Engineer Giovanni Savonuzzi leans on the turbine-engine car he developed for Chrysler in the 1960s.
ANNIE LEIBOVITZ
Page 172: From Getty Images.
Page 174: Bottom, from Photographers Showcase/newscom.com.
Page 176: Courtesy of Mrs. Rina Savonuzzi.
Page 186: Copy work by Alexa Helsell.

LOAD-DATE: September 12, 2006



John Mitchell, "*When Mountains Move*," National Geographic, March 2006

Coal brought people to remote hollows in the Appalachian Mountains of southern West Virginia. And it was coal, or rather a different way of mining it, that finally drove the people away. The last to leave was Judy Bond.

A coal miner's daughter whose roots here go back nine generations, Bond packed up her family and fled when she could no longer tolerate the blasting that rattled her windows, the coal dust that she suspected was coating her grandson's lungs, and the black water spills that bellied up fish in a nearby stream. Retreating to the town of Rock Creek, a few miles downstream, Bond joined Coal River Mountain Watch, a citizens group dedicated to opposing surface-mining abuses.

In the years since Bond moved, coal companies have turned to an even more aggressive mining process known as mountaintop removal. After clear-cutting a peak's forest, miners shatter its rock with high explosives. Then they scoop up the rubble in giant dump lines and dump the overburden, as they call it, into a convenient located hollow, or valley. The method was first tested in Kentucky and West Virginia in the late 1970s and has since spread to parts of Tennessee and Virginia.

"What the coal companies are doing to us and our mountains," said Bond when she and I first met years ago, "is the best kept dirty little secret in America."

Now the secret is out. Coal companies have obliterated the summits of scores of mountains scattered throughout Appalachia, and more and more folks like Judd Bond are decrying the environmental and social fallout of what some refer to as strip mining on steroid.

Not only is mountain topping less labor intensive than underground mining, it is also more efficient and profitable than the older form of surface mining, in which the operator stripped away the horizontal contours of a mountainside as one might peel an apple. So fast has the practice spread that there's no accurate accounting of the area affected, but surface mining in general has impacted more than 400,000 acres (1,600 hectares) in this four-state Appalachian region, including more than 1,200 miles (2,000 kilometers) of streambed. If the practice continues until 2012, it will have squashed a piece of the American earth larger than the state of Rhode Island.

In the years since high-tech earth-moving machinery made mountain topping increasingly attractive to the energy industry, more and more of West Virginia's total production of coal since 1954 (nearly 140 billion metric tons) in 2004 has come from its decapitated highland. Relative to Western coal (Wyoming is the nation's top coal producer), second-ranked West Virginia's low-sulfur bituminous burns with a cleaner, hotter efficiency in the electric power plants of America. And taxes from bituminous coal help fuel a large part of the state's economy.

But some West Virginians have been paying a hurtful price for their state's good fortune and the coal industry's cost-cutting efficiency. In 1948 some 125,000 men worked in the mines of West Virginia. By 2005 there were fewer than 19,000, and most of these were employed in underground mines. Nowadays, it just doesn't take many hands to wrestle coal off the top of a mountain.

Consider, for example, the Big Coal River community of Sylvester, where fewer than 20 of its 195 long-time residents are employed in mining or related services. And consider Sylvester resident Pauline Canterberry. She lives in a small house just a quarter mile down State Route 3 from a coal-washing plant operated by the Elk Run Coal Company, a subsidiary of Massey Energy, West Virginia's premier producer. Canterberry has been waging a decade-long battle with Massey and state and federal regulators over the volume of coal dust wafting from the Elk Run facility and sifting under the sills of Sylvester's homes. She has personal reasons for being concerned about the quality of the air. Her father, Ernest Spangler, died in 1957 from silicosis. His job had been putting out mine fires with buckets of pulverized rock dust. Then in 1991 her husband, John D. Canterberry, died of black lung disease after years of working in underground mines.

"When I was young, Sylvester was the place to be," Canterberry said. "Everyone wanted a home here because the town was so clean. It wasn't a company town. But then Massey came into the valley, and it's been downhill ever since in more ways than one. Now they'll take 300 feet (90 meters) off the top of a mountain just to get at a few feet of coal."

After a long succession of petitions and hearings, 150 Sylvester residents prevailed in their case against Elk Run, forcing the company to pay the litigants economic damages of nearly half a million dollars and requiring it to maintain a dust-trapping cover over its processing plant and to limit the number of coal trucks passing through town to an average of 20 a day. Despite these concessions, Canterberry and some of her activist neighbors are worried about Massey's plans to expand its Elk Run

operations. (Massey representatives did not return repeated phone calls requesting information on its record at Sylvester.)

Several years ago the director of the state's Division of Mining and Reclamation issued a memorandum showing that for the years 2000 and 2001 Massey incurred 500 violations, more than twice the number accumulated by the state's next three largest producers combined. Sixty-two of those violations, most involving excessive coal dust emissions, were attributed to the Elk Run Coal Company at Sylvester.

I grew up beholden to West Virginia bituminous coal. My parents' house in Cincinnati was heated by it until they switched to oil in 1945. The coal came down the Ohio River by barge, and every winter month or so a dump truck would deliver a big pile beside our garage. I remember helping my father cart it to the furnace inside, and the grating screech of his shovel on the cellar floor. And I remember the trail of black soot and the coal dust on my shoes. I was grateful for the warmth the coal gave us, but I hated it too because it was dirty. This was before public health and clean-air regulations obliged the mining industry to wash coal and, in Appalachia at least, dispose of the dust, dirt, and wastewater in impoundments, often perched precariously on the sides of the mountains.

There are some 500 of these impoundments in Appalachia today, more than half in Kentucky and West Virginia. Variously referred to as slurry ponds, sludge lagoons, or waste basins, they impound hundreds of billions of gallons of toxic black water and stick black goo, by-products of cleaning coal, most of from underground mines but also from surface mines. Mountain folk residing downhill from these ponds worry about what a flood of loose sludge might do and has already done in a number of tragic cases.

In Logan County in the winter of 1972, following two straight days of torrential rain, a coal-waste structure built by a subsidiary of the Pittston Coal Company collapsed and spilled 130 million gallons (492 million liters) into Buffalo Creek. The flood scoped up tons of debris and scores of homes as it swept downstream. Survivors recalled seeing houses bobby, at ilt in the swift current, the domed families huddled at their windows. The final count was 125 dead, 1,000 injured, 4,000 made homeless. The Pittston Company called the disaster an "act of God."

In neighboring Kentucky on an October morning in 2000, the bottom of a waste pond near the town of Inez collapsed, pouring 250 million gallons (946 million liters) of slurry 25 times the amount of oil spilled in the Exxon Valdez disaster into an inactive underground mine shaft. From there, the slurry surged to the mine's two exits and flooded two creeks hell-bent for the Tug Fork of the Big Sandy and the Ohio River beyond. Miraculously, there was no loss of human life, though 20 miles (32 kilometers) of stream valley would be declared an aquatic dead zone, water systems in ten counties would have to be shut down, and the black slick would eventually reach out toward the riverfront in Cincinnati. Lawyers for the Martin County Coal Company, a Massey subsidiary and owner of the impoundment, blamed the accident on excessive rainfall, which was simply another way of saying what had been said at Buffalo Creek. It was God's fault.

Fear of impoundment failures haunts the collective memory of West Virginians. "I'm convinced something awful's going to happen again," Freda Williams was saying the day I called on her at her tidy brick house beside a tributary of the Big Coal River, just south of Whitesville. One of the largest waste

basins in the state, the Brush Fork slurry lagoon, owned by Massey Energy, impounds some eight billion gallons of blackwater sludge about three miles upstream from Williams's home.

"What's going to happen to all that water if the dam breaks or the basin collapses into an abandoned underground mine?" By some accounts, should the Brush Fork impoundment ever fail, a wave of sludge 25 feet (7 meters) high could roll over Whitesville in no time flat.

Two other Massey waste impoundments pucker the slopes of the Big Coal Valley. The one at Sundial lies directly above the Marsh Fork Elementary School, with an enrollment of 240 children, from kindergarten through fifth grade. Though Stephanie Timmermeyer, chief of the state's Department of Environmental Protection, has claimed that the Massey facility poses no threat to the school children, the agency's own rating system lists the dam as a Class C facility, meaning its failure could reasonably be expected to cause loss of human life.

Besides the raw scars of the mines themselves, the most startling features of coal country are not necessarily those blackwater basins but the mountain-topped valley fills that have buried hollows and headwater streams under millions of tons of broken rock. Critics fear some fills could eventually come tumbling down in landslides of unpredictable proportions. As one Kentucky attorney likes to put it: "A valley fill is a time bomb waiting to happen."

One of West Virginia's biggest time bombs reaches more than two miles down what used to be, where it was flowing free, the Connell Branch of Mud River in Lincoln County. The fill represents part of a mountaintop the Arch Coal Company unhinged to create the 12,000-acre (4,800-hectare) Hobet 21 mine, one of the largest surface mines in West Virginia. But Hobet 21, now owned by Magnum Coal, has another distinction: For several years it's been home to "Big John," an earth-moving machine with a 20-story clay line and a bucket scoop that swallows over 100 tons of soil and rock in a single bite.

Up the Mud River a short way, a tributary known as Laurel Branch flows sweet and clear beside a weathered white-frame farmhouse. The front porch overlooks a garden of corn and potatoes. From the porch in the spring you can hear the vernal murmur of the creek, though not when the farmhouse is crowded, as it was at the time of my visit, with kin of the Gaudill-Miller clan gathered at a place that has been in the family for a hundred years. Leon and Lucille Miller preside as host and hostess for these occasions. She is one of the surviving heirs of John and Lydia Gaudill, who inherited 75 acres (30 hectares) abutting the Mud and built this farmhouse in 1920. Lucille was raised here, along with nine siblings. But now, for all the copious country food and Gaudill hospitality, an explicable uneasiness lingered at the edge of the festivities. Moving to expand its Hobet 21 operation, Arch Coal had informed the Millers that it was looking to deal with Laurel Branch what it had done to the Connell. And Arch wanted the Gaudill home place out of the way.

"They want it all," Leon Miller told me, "the house and everything. And we're saying, 'No.'"

Since that particular May reunion a few years ago, I have been following the ups and downs of the Millers' struggle to stop Arch Coal from burying Laurel Branch and the ancestral home under the shadow of Hobet 21. Arch did succeed in buying out some of the Gaudill heirs, thereby acquiring a two-thirds interest in the 75 acres (30 hectares). But when Lucille Miller and six of the heirs continued to say

"No," Arch's Ark Land Company filed a lawsuit in Lincoln County Circuit Court arguing that the holdouts should be forced to sell their interests because coal mining was "the highest and best use of the property" and because the cost of protecting the nearby Miller-Caudill land from mining waste would be prohibitive for Arch. Besides, the company's attorneys said, the heirs did not live at the farm but used it only on weekends and other occasions. The circuit court ruled in the company's favor and ordered the property sold at auction. Arch got it. The Millers appealed to the state supreme court and won a reversal of the lower court's ruling. The farmhouses still stand, and the Laurels still murmurs, at least for now.

While Millers and Caudills rallied round their embattled homeplace, a larger but not unrelated issue was unfolding in federal courts and among the agencies responsible for regulating coal mining under the Clean Water Act and the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Under "Stockka," as the act is known, environmentalists contend that the U.S. Office of Surface Mining should enforce a buffer-zone rule prohibiting, in all but the most exceptional cases, any mining activity within one hundred feet of a stream. Under the Clean Water Act, the Army Corps of Engineers was supposed to regulate the actual filling of the streambed itself.

Perceiving a lack of enforcement on both counts, opponents of mountaintop mining in West Virginia have been in and out of court for the past five years, occasionally winning a legal round only to have it set aside on appeal by attorneys for various agencies and the coal industry.

In or out of the courtroom, the argument often boils down to differing opinions as to what constitutes a regulated stream in Appalachia, how vital its upper most reaches might be to the ecological health of the downstream watershed, and finally the degree to which valley fills might contribute to flooding in a peak storm event.

The defenders of valley fills argue that most of these structures affect intermittent streams only and therefore do not fall within the reach of the Army Engineers and the Clean Water Act. William Raney, president of the West Virginia Coal Association, believes many fill areas are simply "dry hollows" for most of the year, implying that they serve little ecological function.

But that's not the way Ben Stout, a biology professor at Wheeling Jesuit University, sees it. According to Stout, aquatic insects in seeps springs at the top of a watershed feed larger life-forms by shredding leaf litter and sending the nutrient-rich particles downstream. "These insects provide the link between a forest and a river," Stout says. "Bury their habitat and you lose the link."

The issue of flooding also evokes conflicting views. Raney sees no connection between mountaintop mining and flood. "Science doesn't bear that out," he told me during an interview in his Charleston office. "What causes flooding is too much water falling in too short a time."

Yet a study by federal regulators, obtained by the Charleston Gazette through the Freedom of Information Act, predicted that one valley fill at the Hobet 21 mine could increase peak runoff flow by as much as 42 percent. Vivian Stockman, a project coordinator with the Ohio Valley Environmental Coalition in Huntington, contend that 12 West Virginians have died since 2001 because of flood related to mountaintop mining. "Old-timers will tell you property that has been in their families for generations

never flooded severely until mining began upstream," Stockman says. "It's common sense. Denuded landscapes don't hold water the way forests do."

It was not the intent of Snacka, of course, to allow coal companies to walk away from their surface mines and leave them denuded. Stripped mountainsides, the law declared, must be restored to their "approximate original contour" and stabilized with grasses and shrubs, and, if possible, trees. But putting the entire top of a topped-off mountain back together again was an altogether different and more expensive matter. So mountaintop mines were given a blanket exemption from this requirement with the understanding that, in lieu of contoured restoration, the resulting plateau would be put to some beneficial public use. Coal boosters claimed the sites would create West Virginia's own Field of Dreams, seeding housing, schools, recreational facilities, and jobs galore. In most cases it didn't work out that way. The most common "use" turned out to be pasture land (in a region ill-suited for livestock production) or what the industry and its regulators like to identify as fish and wildlife habitat.

"The coal companies have stripped off hundreds of thousands of acres," says Joe Lovett, an attorney for the Appalachian Center for the Economy and the Environment, "but they're putting less than one percent of it into productive use."

Yet the industry should get some credit for what it's managed to accomplish in post-mining land use over the years. It's provided a number of West Virginia counties with the flat, buildable space to accommodate two high schools, two "premier" golf courses, a regional jail, a county airport, a 985-acre complex for the Federal Bureau of Investigation near Clarksburg, an aquaculture facility, and a hardwood-flooring plant in Mingo County that now employs 250 workers.

"Economically, we were doing in the vine," said Mike Whitt, executive director of the Mingo County Redevelopment Authority, as we toured the 40-million-dollar flooring plant, financed by grants from federal, state, and local governments and by private investors. "So we got OPM other people's money to get the job done. Without the infrastructure to create jobs, you're out of the game."

One emerging idea to help keep this under-employed region in the game is commercial forestry restoring the land not as pasture or golf course or school but as a reincarnation of what used to be here in the rich diversity of the Appalachian forest. Arch Coal, with test plantings already established east of Whitesville, reports it's eager to pursue this option. "Our intent," says Arch's Larry Emerson, "is not just to approximate what was there before mining but, for the long range, establish a commercial forest."

Some foresters are not convinced that Arch is willing to go far enough in its romance with reforestation. James Burger, a professor of forestry at Virginia Tech University and a zealous proponent of turning topless mountains into productive forests, has found in his studies that weathered brown sandstone soils making up a mountaintop's uppermost layer and therefore the first to be dumped and lost in a valley fill would be better set aside and used, without compaction, as top dressing for any reforestation. But Arch's forestry consultant argues this would raise substantially the per-acre cost of reclamation.

A few environmentalists, such as Joe Lovett of the Appalachian Center, hail Burger's crusade for reforestation as the next best thing to stopping mountaintop mining altogether. Others view it as a cop-out exercise in wishful thinking. "I understand what makes up that forest, and it's not just trees," says Judy Bond of Cal River Mountain Watch. "I'm talking about the herbs and the plants that evolved here in this forest over thousands of years. Re-create that forest? You couldn't do it in 1,500 years."

Standing in the doorway of the Mountain Watch office on the main street of Whitesville, I listened to Judy Bond reminisce about the way it was 50 years ago when she was a child. "I used to swim in the Cal River then," she said, "but now it's so full of silt that the water barely comes up to your knees. It breaks my heart. I look at my grandson, and I see that he's the last generation that will hunt and fish in these mountains and dig for ginseng, and actually know a apple when he sees it. These mountains are in our soul. And you know what? That's what they're stealing from us. They're stealing our soul."

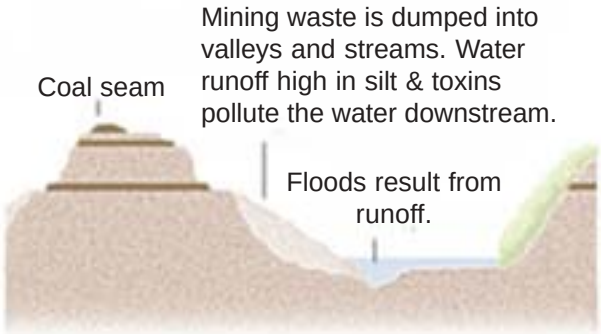
Mountaintop Removal Mining
Stealing Appalachia

Photo by Vivian Stockman, flight by Southwings.org
A massive 20 story dragline, at work on a mountaintop removal operation near Kayford Mountain, West Virginia.

Original Profile

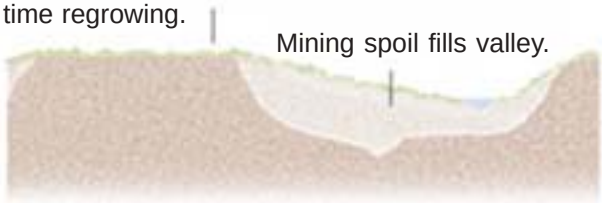
Mountaintop removal

Mining companies strip forests and topsoil, then blast the mountain apart layer by layer to get to coal seams.



Reclamation

Mining waste is smoothed out and steep slopes are terraced. Even with chemical treatments & fertilizers, forests & vegetation at MTR sites have a hard time regrowing.



Adapted from original by
Pattterson Clark--The Washington Post

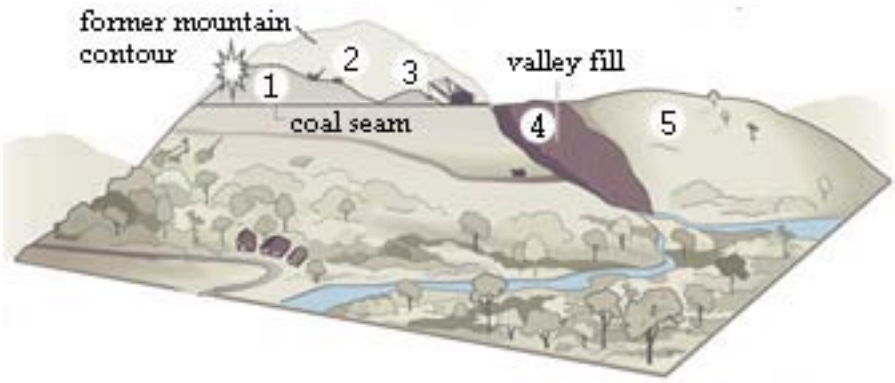
The Future of Appalachia?

With the price of coal skyrocketing, Appalachia is feeling a dramatic increase in surface coal mining practices now destroying entire mountain ranges. Mountaintop removal mining--which includes steep slope strip mining, cross ridge mining, and area mining is currently raveging southern West Virginia, southwestern Virginia, eastern Kentucky and is moving into eastern Tennessee. The communities, mountains, forests, and water of Appalachia are bearing the brunt of these coal mining practices.

Once the mountains are destroyed, the few jobs obtained from this practice will also dissapear, leaving a wake of devastation and unemployment behind. Instead of fishing, hunting, camping, collecting medicinal and edible plants, instead of clean water from healthy watersheds, and clean air in a peaceful community deeply connected with the surrounding mountains, we will be left with the raveged, crumpled, barren remains of what was once the backbone of our Appalachian heritage.

Coal companies are currently obtaining mining permits for vast tracts of mountains in Tennessee. Anderson, Campbell, Claiborne, Scott, and other coal counties will be directly impacted. Tennesseans would do well to look at the devastating affects of mountaintop removal on the people and mountains in West Virginia and Kentucky to see what is in store.

Steps & Effects



1 Forests are clear-cut; often scaping away topsoil, lumber, understory herbs such as ginseng and goldenseal, and all other forms of life that do not move out of the way quickly enough. Wildlife habitat is destroyed and vegetation loss often leads to floods and landslides.

Next, explosives--up to 100 times as strong as those that tore open the Oklahoma City Federal building--blast up to 800 feet off mountaintops. Explosions often cause damage to home foundations and wells. "Fly rock," more aptly named fly *boulder*, can rain off mountains, endangering resident's lives and homes.

2 Huge Shovels dig into the soil and trucks haul it away or push it into adjacent valleys.

3 A dragline (which can weigh up to 8 million pounds with a base as big as a gymnasium and as tall as a 20-story building) digs into rock to expose the coal. It moves 100 or more cubic yards in a single bite--each cubic yard can fill the back of a half-ton pickup truck. Exposives and massive machines allow coal companies to hire fewer workers. A small crew can tear apart a mountain.

4 Giant machines scoop out thin layers of coal, dumping millions of tons of "overburden" – the former mountaintops – into the narrow adjacent valleys, thereby creating valley fills. Coal companies have forever buried over 1,200 miles of biologically crucial Appalachian headwaters streams. In TN the overburden is moved to another location and then "replaced". Aquifers and underground springs are destroyed in this process, making it difficult to impossible for forests to return to the fragmented piles of rubble which were once lush and diverse ecosystems.

5 Coal companies are supposed to reclaim land, but all too often mine sites are left stripped and bare. Even where attempts to replant vegetation have been made, the mountain is never again returned to its healty state.

Community Impacts

Coalfield employment has dropped dramatically in the last 30 years while the tonnage mined and the profits of the big companies have increased. In West Virginia alone, coal employment has dropped from 150,000 workers in the 1960's to 15,000 today. Employment decreases as the use of large expensive machinery and dangerous explosives increase. Steep slope strip mining requires huge amounts of explosives (made with ammonium nitrate and deisel fuel) to blast of the tops of mountains, ridges and the so-called "overburden". In West Virginia alone, three million pounds of explosives are used every day.

Flooding has also become a problem for communities that live in the shadow of these mining sites as forests which slow down and filter rain water are removed. Without vegetation, water cascades over steep slopes, forming intense flash floods. In early July, 2001, devasting floods raged across southern West Virginia. 1500 families lost their homes and thousands more had damaged property. Hundreds of residents were forced to evacuate their homes and community when a State of Emergency was declared, costing 20 million dollars in damages. In May of 2002, intense rain brought more flooding, resulting in the loss of six lives in five counties. Floods returned in July of that same year, and again in 2003 and 2004. So far flooding in southern West Virginia has cost 1.5 billion dollars in damages. Taxpayers, not the profiting coal companies, end up paying for the clean up.

Coal washing often results in thousands of gallons of contaminated water that looks like black sludge and contains toxic chemicals and heavy metals. The sludge, or slurry, is often contained behind earthen dams in huge sludge ponds. One of these ponds broke on February 26th, 1972 above the community of Buffalo Creek in southern West Virginia. Pittston Coal Company had been warned that the dam was dangerous, but they did nothing. Heavy rain caused the pond to fill up and it breached the dam, sending a wall of black water into the valley below. Over 132 million gallons of black wastewater raged through the valley. 125 people were killed, 1100 injured and 4000 were left homeless. Over 1000 cars and trucks were destroyed and the disaster did 50 million dollars in damage. **The coal company called it an "act of God".**

Another coal slurry pond broke in October of 2000. This time it was in Martin County, Kentucky. The pond had leached into an old underground mine shaft and broke out. Over 300 million gallons of the black toxic slurry was released into the headwaters of Coldwater and Wolf Creeks near Inez, Kentucky. Hundreds of area residents had to contend with black, toxic sludge in their yards. This incident remains the largest environmental disaster east of the Mississippi, but it got almost no mention in the national media. The Bush administration effectively shut down the investigation of the incident and the lead inspector resigned in protest. **Massey Coal Company called it "an act of God".**

Mining activity poisons residents. The Independence Coal Company operation in Sundial, WV. has it's coal loading silo within 200 feet Marshfork Elementary School, posing a health risk to both students and teachers. Every day that children spend in class is a risk. Fumes from cancer causing coal-binding chemicals sprayed on the coal as it is loaded onto coal cars, coal dust and other chemicals used used to wash coal, are breathed by children in class or on the playground. When last checked by a concerned resident, the school air intake vents were coated with black soot. The school has been called a 'cancer cluster': a vice principal, three teachers and a 17 year old girl have all died from cancer within the past few years; and another 17 year old student is currently battling ovarian cancer.

The nearby stream has experienced fish populations die off as a result of the toxins such as: chromium, arsenic, mercury, lead, copper, which have been dumped into the water.

The enormous Schumate's Branch sludge dam, which tenuously holds millions of gallons of toxic coal sludge looms above the school. With only one narrow road winding through the valley, evacuation of all of the students--even *if* the school was notified, would be impossible if the dam broke. Blasting increases of sludge dam failure and falling rock hazards children risk while on their school bus route.

Intensive blasting causes problems in surrounding communities. Foundations of homes are cracked and weakened. “Flyrock” (boulders as large as cars that land hundreds of feet from the blast site) causes property damage a safety hazards. Wells of coalfields residents lnear the blast zones are often negatively altered and ground water is often contaminated by toxic runoff from the mines. Many residents have lost their life savings as homes they have invested in are devalued due to blasting damage to foundations, coal dust and dangerous roads.

Three year old Jeremy Davidson was crushed while sleeping in his bed in Wise County, Virginia. In August 2004, A giant boulder was dislodged by a strip mine operator who was working on an unpermitted haul road at two in the morning. The boulder crashed down the mountain like a cannonball, hit a stump, went airborne, and smashed through the back wall of Jeremy’s family home, stopping at the foot of Jeremy’s brother after killing him. **The mining company called it “an act of God”** and was only fined 15,000 dollars. The Davidson family is currently attempting to sue the coal company for Jeremy’s death.

Overweight coal trucks speeding down narrow winding moutain roads have a history of causing many deadly accidents. Many truck operators are paid by the ton, so the faster they drive, the more they get paid. In southern West Virginia, there were 14 deaths from coal truck accidents in an 18 month period between 2000-2001. County taxpayers pay for road degradation due to heavy coal and log truck traffic.

Coal companies use threats and intimidation to get their way. Larry Gibson has been targeted by over 100 instances of violence, threats and property destruction from the coal company because of his refusal to sell his family land and because of his courage in opposing the destruction that now surrounds him. Larry Gibson’s family has owned a patch of Kayford Mountain in West Virginia for multiple generations. The remaining fifty-acres which once sat in a hollow, now perches on a hilltop--almost completely surrounded by the barren remnants of what was once ancient mountains.

Shear cliffs now mark boundaries to his family’s land which has been turned into the Stanley Heirs Foundation Park; both to protect what is left and to educate the public about the destruction of mountaintop removal. From the edge of his land he used to have to look up to see the skyline, now he peers over the edge at 17 miles of devastation in one direction, and over 30 miles in another. With tears in his eyes, he attempted to describe what the mountains used to look like…where family and neighbors once lived and gathered…where livestock grazed… and where he fished, swam and played as a child. Headstones in his family cemetery have been repeatedly knocked over by flyrock . His well and abundant springs have gone dry, the once fertile soil is now coated with mine dust from blasting sites, and the road is now hostile and dangerous both to and from his home. He lives in a battle zone, but refuzes to leave. He has witnessed friends and entire communities evacuate in the path of mountaintop removal. He says that he does not know how much longer he will live, but he will never give up his struggle to save Appalachia.

Both his tireless dedication and the brave work of other affected coalfield residents have awakened what is quickly becoming a national campaign to save Appalachia, Mountain Justice Summer.

Information without an avenue for action, is destructive to the human spirit. It is by making a stand during moments of crisis that we define our futures and our identities. You can make a positive difference. The future of our mountains, communities, heritage and way of life stands upon a crosshair. Join the growing movement to save Appalachia.

Tennessee

Public Land

The Royal Blue Wildlife Management Area, The Big South Fork National Recreation Area & The Don Sunquist Wildlife Management Area are at risk and represent some of the best habitat in the country. These areas are also used for hunting and other forms of outdoor recreation such as white water paddling, fishing, hiking, camping, horseback riding and 4-wheeling.These mountains belong to the people, not to private corporations. The forest represents a good oportunity for gathering medicinal herbs such as ginseng and edible mushrooms and other plant species. Mountaintop removal mining destroys the fabric of the livelihoods of the local people and endangers their very existance. Many locals in other areas in which this type of mining has been practices were forced to move for fear of being swept away in floods or landslides.

Large landslides have already been documented (as of March, 2005) on the site of a pending permit from National Coal Corporation as a result of past surface mining--after "reclamation" to federal standards. This demonstrates the instability of these slopes without the forest vegetation that has evolved on these mountains over a milenia.

The Cumberland Mountains cut across Tennessee roughly midway between Knoxville and Nashville. The southern part is divided by the Sequatchie Valley. Outdoor enthusiasts find plenty to love here, and of those who come for a visit, many decide to stay. People from all over the world come to enjoy the mountains of Appalachia and tourism dollars provide a much needed boost the economy.

Water & Life

Excerpts from the May 21, 2005 *Knoxville News Sentinal* article by Scott Barker

The New River feeds the Big South Fork of the Cumberland River, the centerpiece of the Big South Fork National River and Recreation Area. Water quality in the New River, which is just now recovering from past mining, could be threatened.

Throughout this region where the Cumberland Plateau breaks up into low but rugged peaks, the legacy of coal mining shows itself as great gouges in the flanks of the mountains.

Highwalls soar above pits filled with sulfur water and mountaintops are ringed with shelves, making them look like green top hats. Acid mine drainage is one of the more serious environmental hazards from coal mining. Mining operations expose iron pyrite to oxygen and water, a reaction that produces sulfuric acid. The runoff poisons streams.

Since the passage of the 1977 surface mining law, mining companies have been required to reclaim mines as they finish extracting the coal. Previously, however, companies would just leave once the coal played out.
Tennessee has spent $27 million cleaning up abandoned mine sites over the past two decades, but officials say they would have to spend another $27 million to clean up all the problems.

Tim Eagle, who runs the state's reclamation program, said it would take $14.2 million to clean up just the sites that pose imminent health and safety risks.

Reclamation money comes from the federal Abandoned Mine Lands program, but Tennessee only receives a fraction of the pot — between $1 million and $1.5 million a year. That's because the state abdicated its regulatory role over coal mining to the OSM in 1984.

The federal funding, however, could end this year. The Abandoned Mine Lands program expired last year and Congress has given it two extensions, but sectional rivalries could scuttle the funding.

Mining operators fund the program through a fee, currently 35 cents a ton for strip-mined coal and 10 cents a ton for deep-mined coal. But operators in Western states, which don't have pre-1977 abandoned mines, don't want to pay for reclamation projects in the East. Some of the proposals to reauthorize the program would funnel more money to Tennessee, but attempts to reach a compromise have failed so far.

Reporting Violations

Blasting Rules

Coal companies in Tennessee can only use explosives between sunrise and sunset according to the Office of Surface Mining (OSM) regulations (30 C.F.R. 942.816 (h)). Except in emergency situations, companies can only blast at the times set forth in their blasting schedule which can be obtained from OSM. Companies are required to publish the blasting schedule in a newspaper in the area where the blasting will take place at least 10-30 days before beginning to blast. In addition, each resident within a half mile of the blasting site must receive a copy of the blasting schedule.

Companies are not allowed to blast if it will injure people, damage public or private property outside of the permit area, cause damage to underground mines, or change the course, channel, or availability of surface or groundwater outside the permit area (30 C.F.R. 816.67 (a)).

Flyrock travelling in the air or along the ground must not be cast from the permit boundary or more than 1/2 of the distance to the nearest dwelling or occupied structure (30 C.F.R. 816.67 (c)).

Water Quality, Floods & Landslides

Coal companies must not pollute Tennessee's waters, either above or below the ground. Some examples of pollution include: flooding, muddy water or acidified water (aquamarine colored), bulldozed or filled waterways, chemicals dumped or leached into the water, fish kills and landslides impacting waterways. Permits from the Tennessee Department of Environment and Conservation (TDEC) are required in order to change surface or ground water in any way.

Report Violations or Complaints to:

Dave Turner at TDEC 865-594-6035
dave.turner@state.tn.us

Report blasting violations or complaints to:

State Fire Marshall's Office 865-594-5719
email: dennis.thorne@state.tn.us

Office of Surface Mining 865-545-4039
530 S. Gay St. #500 Knoxville, TN 37902

BLAST CHART

Name:_____

Location:_____

Date	Time	Remarks

REMARKS: Record the severity of the blast (can you feel it in your feet?), specific damages (including house foundation damage and damage to wells), and any personal physical or emotional trauma caused.

Trucks, Traffic & Safety

Coal trucks may not cause damage to public road surfaces and must obey all traffic laws and regulations including speed limits and rules of the road (no reckless driving). Coal trucks must have a permit from TDOT to operate which must be in the dirver's possession.

Report safety violations, damage to your property or public property, threats or intimidation to:

Your local Sheriff's Department

Maintain records of reported violations. You can also report these violations to Mountain Justice Summer. You may specify if you wish to remain anonymous.

Permits & Hearings

Coal companies must have at least three permits before mining. They must have a permit for the mining operation from OSM. They must also have at least two water permits from TDEC, which concerns mining effects upon water quality. If they are going to fill or conduct other alterations to a stream, the company must have a permit from the Army Corp of Engineers. Citizens concerned about mining impacts can request a public hearing on these permits.

Look for permits: scan your local newspaper for new permits in your area and ask for a public hearing, alert your neighbors. You can make a difference.

Requesting Public Hearings

To learn about new and pending mining permits or to request a hearing on mining permists contact:

Doug Siddell
Office of Surface Mining
530 S. Gay St. #500
Knoxville, TN 37902

OSM hearing requests must be in writing. In your request state the issues you want to bring up at the hearing and why you will be negatively affected by the mining.You may also request to be allowed to visit the site of the mine. Be sure to get your request in before the deadline.

To learn about new and pending water permits issued by the state of Tennessee, or to request a hearing on these permits contact:

Dave Turner: dave.turner@state.tn.us

TDEC, Knoxville Field Office
2700 Middlebrook Pike
State Plaza Building, Suite 220
Knoxville, TN 37921

FAX: (865) 594-6105

TDEC hearing requests must also be in writing and should include: why TDEC should hold the hearing, how the permit will affect water quality, why you will be negatively affected and that there is a lot of public interest in the permit. Be sure to get your request in before the deadline.

For permit and hearing updates you can also go to

www.mountainjusticesummer.org

Your mountains, your heritage,
your children's future.

Will Governor Bredesen do his job?

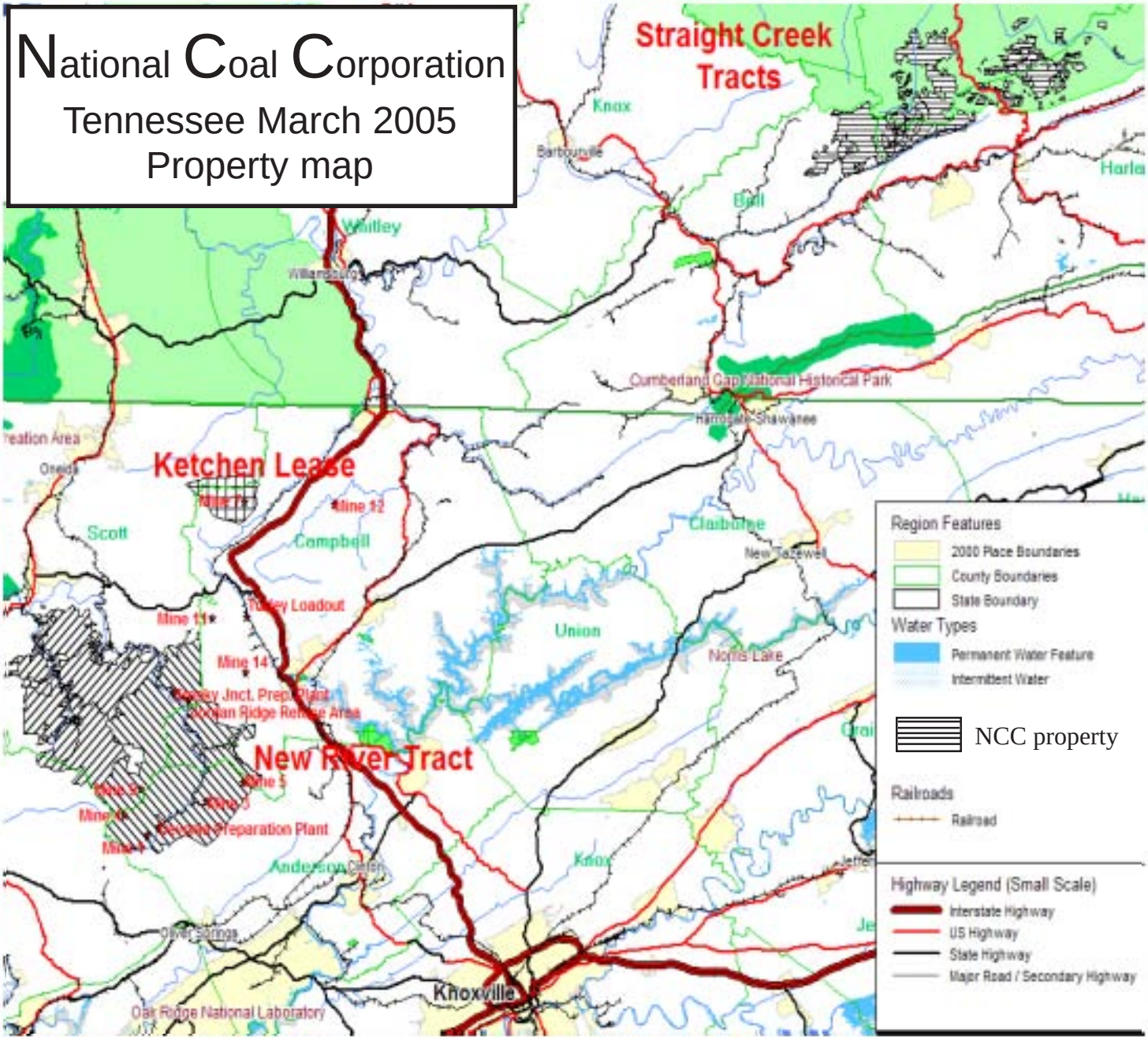
Phil Bredesen, the 48th governor of Tennessee, took office in 2003, with a promise of being the "environmental governor" and of making "government work on behalf of its citizens for the betterment of the entire state." Instead--Bredesen and his administration have flung open the doors to mountaintop removal mining, in clear violation of the laws they swore to uphold. He's given the keys to out of state coal barons, theives who will steal our mountains and leave us only the ragged remains. Instead of fishing, hunting, camping, collecting medicinal and edible plants, instead of clean water from healthy watersheds, and clean air in a peaceful community deeply connected with the surrounding mountains, we will be left with the raveged, crumpled, baren remains of what was once the backbone of our Appalachian heritage.

Mountaintop removal minng is the final theft of our heritage. Once the mountains are gone, the few jobs obtained from this practice at the expense of everyone else in the community will also be gone, leaving a wake of devastation and unemployment behind. Only God can built a mountain. The people of Appalachia have a long history of devotion to God, family, community and country. It is time this country's government is called upon to do it's job, to remember the people and mountains of Appalachia.

Contact Phil & ask him to do his job.

Governor's Office
Tennessee State Capitol
Nashville, TN 37243-0001

Phone: 615.741.2001
Fax: 615.532.9711



Cross-ridge mining is blowing up our mountains to get to thin irregular contoured coal seams. Tennessee has 24 active coal mines, 17 of them are surface operations. Another 30 sites have permits, but have temporarily ceased activity. Just three companies — Mountainside Coal Co., Appolo Fuels Inc. and National Coal — account for more than half the active mines.

National Coal Company (NCC) is a Florida based company that was formed in January 2003. NCC is currently slicing off three of the peaks of Zeb Mountain near Elk Valley in Campbell County, TN. A quote from the NCC web site stated that "The majority of this property has been mined minimally over the last one hundred years, but nowhere near the extent to which NCC plans on mining the area." NCC has gained ownership of mineral rights for 115,000 acres in the North Cumberland mountains, and is currently clearing and mining portions of this property. Within its short existance, NCC has already established a reputation for lying and bullying. NCC is attempting to shut up it's critics with a lawsuit based on lies. NCC's engineer threatend a citizen with a lawsuit for participating in a public hearing.

Mountainside Mining and Triple H are also gearing up for new mountaintop removal mines in east Tennessee. Mountainside Coal Company is being granted huge interconnected mines which will destroy Egan Mountain and the communities around it. Egan Mountain Mine is in Tennessee on the Campbell / Claiborne county border near Kentucky. Before their permits are even granted, this Kentucky company has already begun savaging the area.

Myths and Facts

Myth:
Mountaintop removal mining provides jobs.

Fact: As more coal is produced in mountaintop removal strip mining, the number of coal mine workers decreases. Although coal production rose 32 percent between 1987 and 1997, mining jobs dropped 29 percent during the same period. *Source: Citizens Coal Council; http://www.citizenscoalcouncil.org/facts/mtntop.htm*

Myth: Mountaintop removal mining improves local economies.

Fact: The top 15 coal producing counties in West Virginia (where mountaintop removal mining has been in practice the longest) suffer from some of the worst poverty levels in the nation, even though they produce 15% of the nation's coal. *Source: United States Census Bureau; West Virginia Office of Miners' Health, Safety and Training*

Fact: In 1998, tourism pumped far more money into the West Virginia economy than the coal industry. *Source: Citizens Coal Council; http://www.citizenscoalcouncil.org/facts/mtntop.htm*

Fact: Coal companies force people living near the mines to sell their homes and leave. Whole communities, such as Blair, West Virginia, have been wiped out. *Source: Source: Citizens Coal Council; http://www.citizenscoalcouncil.org/facts/mtntop.htm*

Myth: Mountaintop removal mining does not harm the environment; rather it maintains or improves the quality of local ecosystems

Fact: In just the last decade, mountaintop removal has obliterated the natural beauty that took millions of years to form. Mines in West Virginia alone have buried over 1,000 miles of streams and cut down over 300,000 acres of hardwood forests, eliminating hunting, fishing, camping and wildcrafting opportunities. *Source: Source: Citizens Coal Council; http://www.citizenscoalcouncil.org/facts/mtntop.htm*

Fact:The natural return of forests to mountaintop mines reclaimed with grasses under hay and pasture or wildlife post-mining land uses occurs very slowly. Full reforestation across a large mine site in such cases may not occur for hundreds of years. *Source: Earth Crash Earth Spirit; http://eces.org/articles/static/98886600092645.shtml*

Fact: West Virginia's Coal River was named one of the country's ten most endangered rivers in 1999 and 2000 because of the environmental danger posed by mountaintop removal and valley fills. *Source: West Virginia Rivers Coalition; http://www.wvrivers.org/whatismtr.htm*

Myth: All surface-mined land today is reclaimed equal to or better than it was prior to mining.

Fact: The Appalachian Highlands is characterized by some of the best forest habitat in the world. Current reclamation practices are converting these forests into grasslands, which may significantly impact neotropical bird populations and other sensitive species if left unchanged. *Source: Source: Trial Lawyers for Public Justice; http://www.tlpj.org/EPAslideshow.htm*

Fact: In the original mining permit application, companies are required to include specific details which demonstrate that the land can and will be put to some productive use, such as recreational, commercial, agricultural, etc. Curiously, a number of mountaintop removal permits have been approved which included no specific details about post-mining land use. *Source: http://www.geocities.com/RainForest/Vines/9638/reclaim.html*

Some Coal companies destroying Appalachia

Arch Coal Inc.
One City Place Dr., Suite 300 St. Louis, MO 63141
314.994.2700, 1.800.360.4519

National Coal Corporation
8915 George Williams Rd. Knoxville, TN 37923
Phones: 865-769-3749, 865-690-6900, 866-703-COAL
Fax: 865.691.9982

Mountainside Coal Co.
7692 South Highway 25W
Williamsburg, KY 40769

Crestview Capital Funds
95 Revere Drive, Suite A, Northbrook, IL 60062
Phone: 847.559.0060 Fax: 847.559.5807

Cunningham & Company
730 W. Randolph St., 6th Floor Chicago, IL 60661
Phone: 312.876.1070 Fax: 312.454.0261

Massey Energy
4 North 4th Street, Richmond, VA 23219
Phone: 888.424.2417, 804.788.1824

West Virginia Coal Association
P.O. Box 3923, Charleston, WV 25339
Phone: 304.342.4153 Fax: 304.342.7651

Do we need MTR coal?

Mountaintop Removal Mining (MTR) and other forms of surface mining only provide an average of 4-5% of the nation's coal energy. With energy conservation alone, we could save an average of 20% of our current energy demands. MTR mining is not needed and serves only to provide short term profits for a few, while causing long term devastation to the mountain ecosystems and surrounding communities.

MJS encourages conservation, efficiency, solar and wind energy as alternatives to Mountain Top Removal and all forms of surface mining.

According to the U.S. Department of Energy, the world's winds could supply more than 10 times the current total world energy demand. With today's wind turbine technology, wind power could supply 20% of the United States' electricity.

Help protect our mountains
www.mountainjusticesummer.org

Mountian Justice Summer

Mission Statement

Mountain Justice Summer (MJS) seeks to add to the growing anti-MTR citizens movement. Specifically MJS demands an abolition of MTR, steep slope strip mining and all other forms of surface mining for coal. We want to protect the cultural and natural heritage of the Appalachia coal fields. We want to contribute with grassroots organizing, public education, nonviolent civil disobedience and other forms of citizen action.

Historically coal companies have engaged in violence and property destruction when faced with citizen opposition to their activities. MJS is committed to nonviolence and will not be engaged in property destruction.

Why Mountain Justice Summer

Mountain Justice Summer is a call to action and a request for help.

Over 1200 miles of stream have been buried and destroyed and countless mountains and ridge tops have been blown up. Additionally, under the Bush administration laws have been altered to encourage and accelerate the destruction. Our state and federal agencies charged with protecting our environment are liquidating our mountains.

Moutaintop Removal Mining destroys watersheds. Water is going to matter more to future generations. **The Pentagon has predicted than many of the future wars on our planet will not be fought over coal or oil–but for water.** The short term profits of large corporations are at the expense of our collective future. Now more than ever we must unite and demand the future we desire. A life for our grandchildren and great-grandchildren.

We do not want to see the coal companies get away with their current devastation. We demand that they halt all forms of mountaintop removal mining or destructive surface mining practices and employ the good people of Appalachia in sustainable jobs such as: restoration of past mine sites, investment in green energy, and responsible deep mining. We also demand financial reparations for the damages that they have done to the mountains and people of Appalachia.

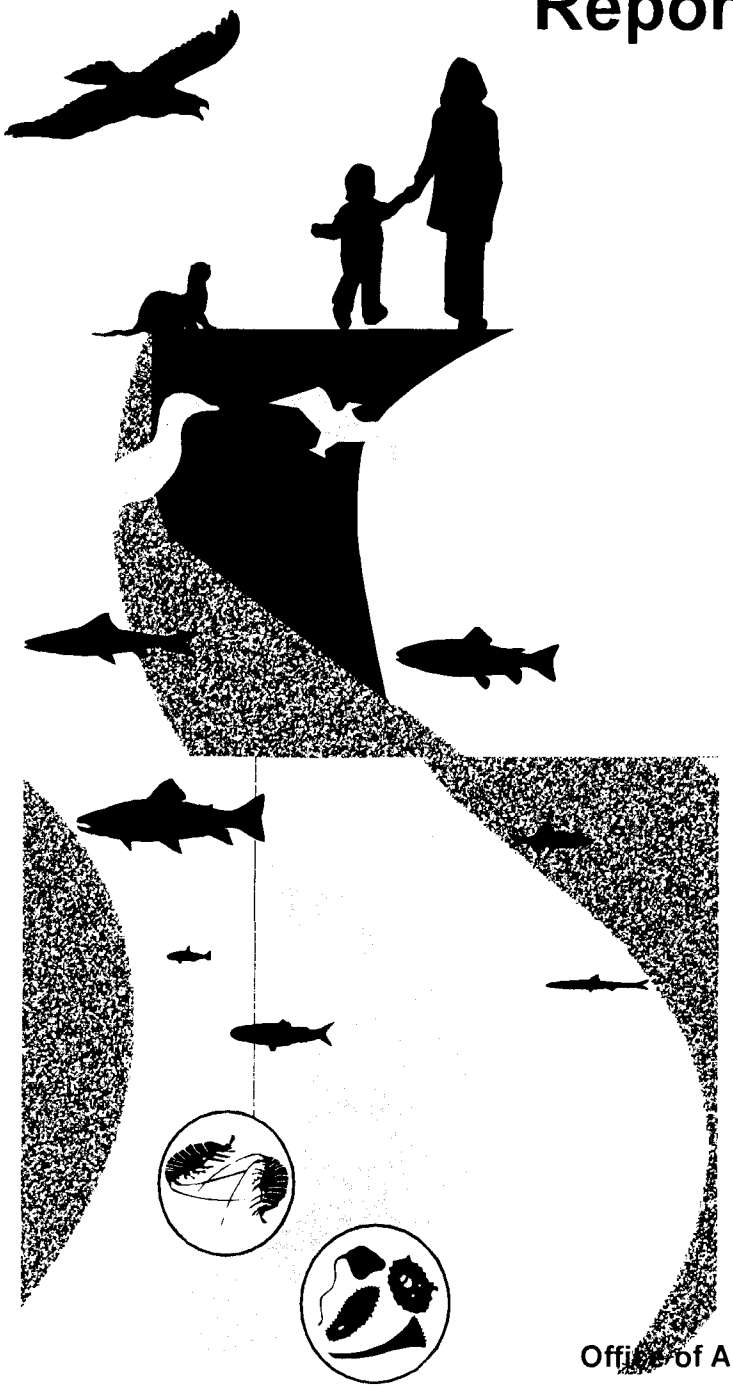
United States
Environmental Protection
Agency

Air

EPA-452/R-97-003
December 1997

Mercury Study Report to Congress

Volume I: Executive Summary



EPA

Office of Air Quality Planning & Standards
and
Office of Research and Development

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MERCURY STUDY REPORT TO CONGRESS

VOLUME I:

EXECUTIVE SUMMARY

December 1997

Office of Air Quality Planning and Standards
and
Office of Research and Development

U.S. Environmental Protection Agency

DEDICATION

The U.S. EPA scientists who authored this Report dedicate their efforts to the memory of their colleague, Terry Clark. Terry began his career at the U.S. EPA in 1975, where he became a national, and then an international expert in the atmospheric transport of acid rain and toxic trace gases. Terry designed the initial long-range transport analysis for the Mercury Study. The energy and creativity he brought to his work sustained him even through the final months of his illness when he continued to work daily on this Report. His honesty, intelligence and generosity of spirit are greatly missed. Terry Clark died on January 28, 1994.

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LIST OF SYMBOLS, UNITS AND ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation factor
bw	Body weight
CAA	Clean Air Act as Amended in 1990
CH_3Hg	Monomethylmercury
$(CH_3)_2Hg$	Dimethylmercury
CSFII	U.S. Department of Agriculture's Continuing Surveys of Individual Food Consumption
H_2S	Hydrogen sulfide
Hg^0	Elemental mercury
Hg(II)	Mercuric ion (divalent mercury)
HgS	Mercuric sulfide
U.S. EPA	U.S. Environmental Protection Agency
U.S. FDA	U.S. Food and Drug Administration
GACT	Generally available control technology
g	Gram
HAP	Hazardous Air Pollutant
kg	Kilogram (1,000 grams)
km	Kilometer (1,000 meters)
MACT	Maximum achievable control technology
Mg	Megagram (one million grams or one metric ton)
NHANES	National Health and Nutrition Examination Survey
ORD	U.S. EPA Office of Research and Development
PBPK	Physiologically-based pharmacokinetic
pg	Picogram (10^{-12} gram)
ppm	Part per million
RfC	Reference concentration
RfD	Reference dose
μg	Microgram (10^{-6} gram)
WC	Wildlife criterion
WHO	World Health Organization
WHO/IPCS	World Health Organization's International Programme for Chemical Safety
yr	Year

OVERVIEW

This Mercury Study is a Report to Congress prepared by the U.S. Environmental Protection Agency. It fulfills the requirements of section 112(n)(1)(B) of the Clear Air Act, as amended in 1990. The Report provides an assessment of the magnitude of U.S. mercury emissions by source, the health and environmental implications of those emissions, and the availability and cost of control technologies. As the state-of-the-science for mercury is continuously and rapidly evolving, this Report should be viewed as a "snapshot" of our current understanding of mercury. This Report does not quantify the risk from mercury exposure because of scientific uncertainty in a number of important areas. The Report identifies areas where further research is needed to provide a quantitative risk assessment.

Mercury cycles in the environment as a result of natural and human (anthropogenic) activities. The amount of mercury mobilized and released into the biosphere has increased since the beginning of the industrial age. Most of the mercury in the atmosphere is elemental mercury vapor, which circulates in the atmosphere for up to a year, and hence can be widely dispersed and transported thousands of miles from likely sources of emission. Most of the mercury in water, soil, sediments, or plants and animals is in the form of inorganic mercury salts and organic forms of mercury (e.g., methylmercury). The inorganic form of mercury, when either bound to airborne particles or in a gaseous form, is readily removed from the atmosphere by precipitation and is also dry deposited. Wet deposition is the primary mechanism for transporting mercury from the atmosphere to surface waters and land. Even after it deposits, mercury commonly is emitted back to the atmosphere either as a gas or associated with particles, to be re-deposited elsewhere. As it cycles between the atmosphere, land, and water, mercury undergoes a series of complex chemical and physical transformations, many of which are not completely understood.

Mercury accumulates most efficiently in the aquatic food web. Predatory organisms at the top of the food web generally have higher mercury concentrations. Nearly all of the mercury that accumulates in fish tissue is methylmercury. Inorganic mercury, which is less efficiently absorbed and more readily eliminated from the body than methylmercury, does not tend to bioaccumulate.

Mercury Emissions and Deposition in the U.S.

The best point estimate of annual anthropogenic U.S. emissions of mercury in 1994-1995 is 158 tons. Roughly 87 percent of these emissions are from combustion sources, including waste and fossil fuel combustion. Contemporary anthropogenic emissions are only one part of the mercury cycle. Releases from human activities today are adding to the mercury reservoirs that already exist in land, water, and air, both naturally and as a result of previous human activities. The flux of mercury from the atmosphere to land or water at any one location is comprised of contributions from the natural global cycle including re-emissions from the oceans, regional sources, and local sources. Local sources could also include direct water discharges in addition to air emissions. Past uses of mercury, such as fungicide application to crops are also a component of the present mercury burden in the environment. One estimate of the total annual global input to the atmosphere from all sources including natural, anthropogenic, and oceanic emissions is 5,500 tons. Based on this, U.S. sources are estimated to have contributed about 3 percent of the 5,500 tons in 1995.

A computer simulation of long-range transport of mercury suggests that about one-third (~ 52 tons) of U.S. anthropogenic emissions are deposited, through wet and dry deposition, within the lower 48 States. The remaining two-thirds (~ 107 tons) is transported outside of U.S. borders where it diffuses into the global reservoir. In addition, the computer simulation suggests that another 35 tons of mercury from the global reservoir is deposited for a total deposition of roughly 87 tons. Although this type of

modeling is uncertain, the simulation suggests that about three times as much mercury is being added to the global reservoir from U.S. sources as is being deposited from it. What is not uncertain is that additional emissions to air will contribute to levels in the global reservoir, and concomitant deposition to water bodies.

The highest deposition rates from anthropogenic and global contributions for mercury are predicted to occur in the southern Great Lakes and Ohio River valley, the Northeast and scattered areas in the South, with the most elevated deposition in the Miami and Tampa areas. The location of sources, the chemical species of mercury emitted and the climate and meterology are key factors in mercury deposition. Humid locations have higher deposition than arid locations.

Public Health Impacts

Epidemics of mercury poisoning following high-dose exposures to methylmercury in Japan and Iraq demonstrated that neurotoxicity is the health effect of greatest concern when methylmercury exposure occurs to the developing fetus. Dietary methylmercury is almost completely absorbed into the blood and distributed to all tissues including the brain; it also readily passes through the placenta to the fetus and fetal brain. The reference dose (RfD) is an amount of methylmercury, which when ingested daily over a lifetime is anticipated to be without adverse health effects to humans, including sensitive subpopulations. At the RfD or below, exposures are expected to be safe. The risk following exposures above the RfD is uncertain, but risk increases as exposures to methylmercury increase.

Extrapolating from the high-dose exposures that occurred in the Iraq incident, the U.S. EPA derived a RfD for methylmercury of 0.1 μg/kg bw/day. While the U.S. EPA has been advised by scientific reviewers to employ this RfD for this analysis, new data are emerging. Currently ongoing are two large epidemiology studies in the Seychelle Islands and in the Faroe Islands that were designed to evaluate childhood development and neurotoxicity in relation to fetal exposures to methylmercury in fish-consuming populations. Because of various limitations and uncertainties in all of the available data, the U.S. EPA and other Federal agencies intend to participate in an interagency review of the human data on methylmercury, including the most recent studies from the Seychelle Islands and the Faroe Islands. The purposes of this review are to refine the estimates of the level of exposure to mercury associated with subtle neurological endpoints and to further consensus between all of the Federal agencies. After this process, the U.S. EPA will determine if a change in the RfD for methylmercury is warranted.

Fish consumption dominates the pathway for human and wildlife exposure to methylmercury. This study supports a plausible link between anthropogenic releases of mercury from industrial and combustion sources in the United States and methylmercury in fish. However, these fish methylmercury concentrations also result from existing background concentrations of mercury (which may consist of mercury from natural sources, as well as mercury which has been re-emitted from the oceans or soils) and deposition from the global reservoir (which includes mercury emitted by other countries). Given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of mercury (such as natural sources and re-emissions from the global pool). As a result, it cannot be assumed that a change in total mercury emissions will be linearly related to any resulting change in methylmercury in fish, nor over what time period these changes would occur. This is an area of ongoing study.

Critical elements in estimating methylmercury exposure and risk from fish consumption include the species of fish consumed, the concentrations of methylmercury in the fish, the quantity of fish consumed, and how frequently fish is consumed. The typical U.S. consumer eating fish from restaurants

and grocery stores is not in danger of consuming harmful levels of methylmercury from fish and is not advised to limit fish consumption. The levels of methylmercury found in the most frequently consumed commercial fish are low, especially compared to levels that might be found in some non-commercial fish from fresh water bodies that have been affected by mercury pollution. While most U.S. consumers need not be concerned about their exposure to methylmercury, some exposures may be of concern. Those who regularly and frequently consume large amounts of fish -- either marine species that typically have much higher levels of methylmercury than the rest of seafood, or freshwater fish that have been affected by mercury pollution -- are more highly exposed. Because the developing fetus may be the most sensitive to the effects from methylmercury, women of child-bearing age are regarded as the population of greatest interest. In this Report, an analysis of dietary surveys led the U.S. EPA to conclude that between 1 and 3 percent of women of child-bearing age (i.e., between the ages of 15 and 44) eat sufficient amounts of fish to be at risk from methylmercury exposure, depending on the methylmercury concentrations in the fish. These consumers should be aware of the Food and Drug Administration and State fish advisories that suggest limiting the consumption of contaminated fish. Advisories in the United States have been issued by 39 states and some Tribes, warning against consumption of certain species of fish contaminated with methylmercury.

To the extent that concern is focused on high-end fish and seafood consumers, research is needed on the actual consumption patterns and estimated methylmercury exposure of this subpopulation. In addition, the findings from such research should be validated by analysis of hair samples from a representative sample of members of this subpopulation.

Environmental Impacts

The pattern of mercury deposition nationwide influences which eco-regions and eco-systems will be more highly exposed. Piscivorous (fish-eating) birds and mammals are more highly exposed to mercury than any other known component of aquatic ecosystems. Adverse effects of mercury on fish, birds and mammals include death, reduced reproductive success, impaired growth and development, and behavioral abnormalities.

Mercury contamination has been documented in the endangered Florida panther and the wood stork, as well as populations of loons, eagles, and furbearers such as mink and otter. These species are at high risk of mercury exposure and effects because they either are piscivores or eat piscivores. Concentrations of mercury in the tissues of wildlife species have been reported at levels associated with adverse health effects in laboratory studies with the same species. However, field data are insufficient to conclude whether piscivorous wading birds or mammals have suffered adverse effects due to airborne mercury emissions. Modeling analyses conducted for this Report suggest that it is probable that individuals of some highly exposed wildlife subpopulations are experiencing adverse effects due to airborne mercury emissions.

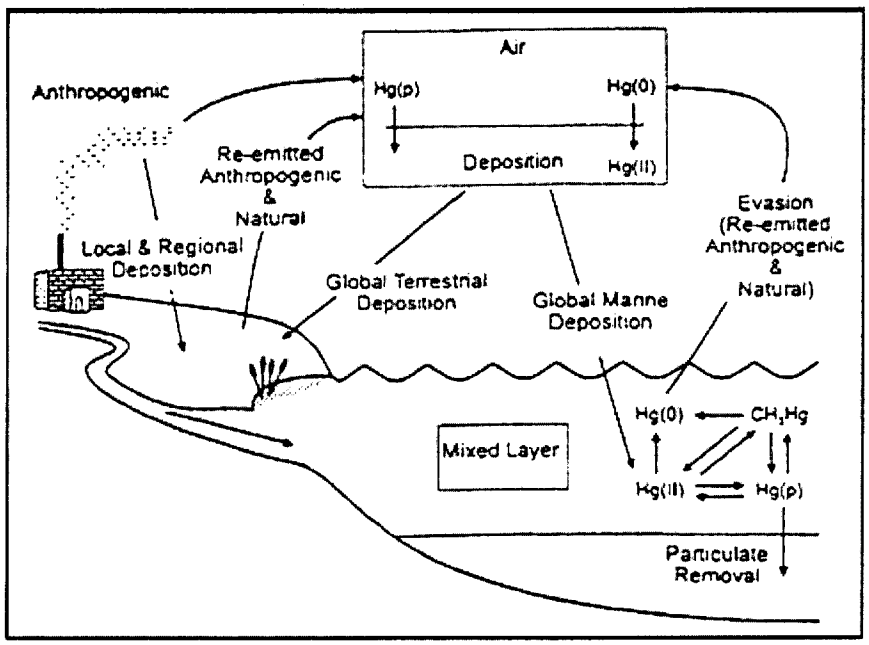
Mercury Control Technologies

Mercury is widely used in industry because of its diverse properties and serves as a process or product ingredient in several industrial sectors, however, industrial demand for mercury has declined by about 75 percent between 1988 and 1996, due largely to the elimination of mercury additives in paints and pesticides and the reduction of mercury in batteries. Most of the emissions of mercury are produced when waste or fuel containing mercury is burned. The U.S. EPA has already finalized emission limits for municipal waste combustors and medical waste incinerators. As a result, by the year 2000, emissions from these categories will decline at least 90 percent from 1995 levels. In addition, mercury emission limits have been proposed for hazardous waste incinerators.

The Role of Atmospheric Releases and Processes

A schematic of the most recent conceptualization of the current global mercury cycle is presented in Figure 2-1. As indicated in this figure, mercury is emitted to the atmosphere by a variety of sources, dispersed and transported in the air, deposited to the earth, and stored in or transferred between the land, water, and air.

Figure 2-1
The Global Mercury Cycle



Source: Adapted from Mason, R.P., Fitzgerald, W.F., and Morel, M.M. 1994. The Biogeochemical Cycling of Elemental Mercury: Anthropogenic Influences. *Geochim. Cosmochim. Acta*, 58(15):3191-3198.

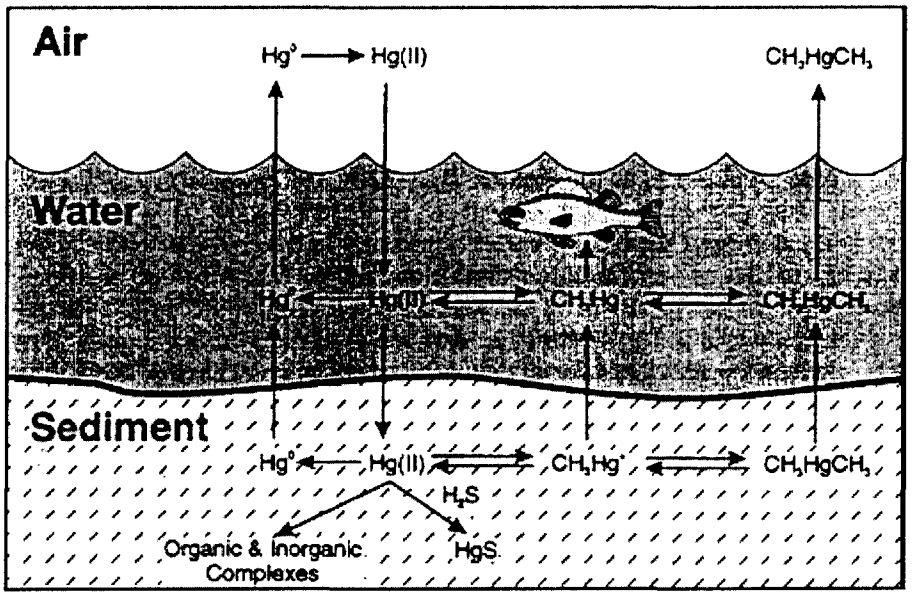
Mercury deposits on the earth in different ways and at different rates, depending on its physical and chemical form. Mercuric species are subject to much faster atmospheric removal than elemental mercury. Mercuric mercury bound to airborne particles and in a gaseous form is readily scavenged by precipitation and is also dry deposited (that is, deposited in the absence of precipitation). In contrast, elemental mercury vapor has a strong tendency to remain airborne and is not susceptible to any major process resulting in direct deposition to the earth's surface. Although much uncertainty still exists, several studies indicate that the relative contribution of mercury loadings to land and water from atmospheric deposition can be substantial.

Numerous studies of elevated mercury levels in remote locations, where atmospheric transport and deposition appears to be the primary mechanism for contamination, provide further evidence of the importance of the atmospheric pathway.

Fate and Transport of Mercury in the Environment

The movement and distribution of mercury in the environment can be confidently described only in general terms. There has been increasing consensus on many, but not all, of the detailed behaviors of mercury in the environment. The depiction of the mercury cycle in Figure 2-2 illustrates the major transfer and transformation processes expected to occur. These processes include a number of infinite and/or indefinite loops.

Figure 2-2
Cycling of Mercury in Freshwater Lakes



Source: Adapted from Winfrey, M.R. and J.W.M. Rudd. 1990. Review -- Environmental Factors Affecting the Formation of Methylmercury in Low pH Lakes. *Environ. Toxicol. Chem.* 9:853-869.

Mercury cycling and partitioning in the environment are complex phenomena that depend on numerous environmental parameters. The following points generally describe the key factors that affect the fate and transport of mercury in the environment.

- The form of mercury in air affects both the rate and mechanism by which it deposits to earth.

- Wet deposition apparently is the primary mechanism for transporting mercury from the atmosphere to surface waters and land.

- Once in aquatic systems, mercury can exist in dissolved or particulate forms and can undergo a number of chemical transformations (see Figure 2-2).

- Contaminated sediments at the bottom of surface waters can serve as an important mercury reservoir, with sediment-bound mercury recycling back into the aquatic ecosystem for decades or longer.

- Mercury has a long retention time in soils. As a result, mercury that has accumulated in soils may continue to be released to surface waters and other media for long periods of time, possibly hundreds of years.

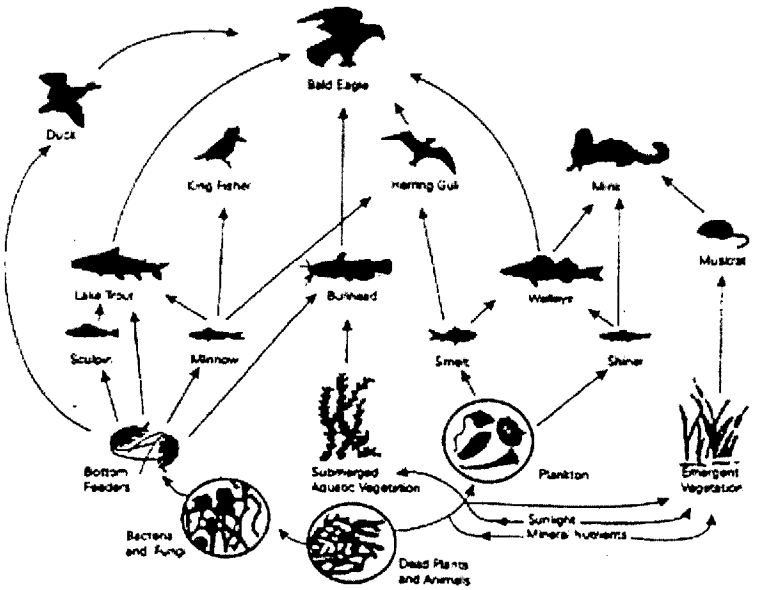
Potential Exposure Pathways

Plants, animals and humans can be exposed to mercury by direct contact with contaminated environmental media or ingestion of mercury-contaminated water and food.

Generally, mercury accumulates up aquatic food chains so that organisms in higher trophic levels have higher mercury concentrations. An example aquatic food web is shown in Figure 2-3. At the top trophic levels are piscivores, such as humans, bald eagles, cormorants, herring gulls and other fish-eating species. The larger wildlife species (e.g., bald eagle, otter) can prey on fish that occupy high trophic levels, such as trout and salmon, which in turn feed on smaller "forage" fish. Smaller piscivorous wildlife (e.g., kingfishers, ospreys) tend to feed on the smaller forage fish, which in turn feed on zooplankton or benthic invertebrates. Zooplankton feed on phytoplankton and the smaller benthic invertebrates feed on algae and detritus. Thus, mercury is transferred and accumulated through several trophic levels.

Figure 2-3

Example Aquatic Food Web



Mercury Methylation and Bioaccumulation

Methylation of mercury is a key step in the entrance of mercury into food chains. The biotransformation of inorganic mercury species to methylated organic species in water bodies can occur in the sediment and the water column. All mercury compounds entering an aquatic ecosystem, however, are not methylated; demethylation reactions as well as volatilization of dimethylmercury decrease the amount of methylmercury available in the aquatic environment. There is a large degree of scientific uncertainty regarding the rate at which these reactions take place. There is general scientific agreement however that there is significant variability between waterbodies concerning the environmental factors that influence the methylation of mercury.

Nearly 100% of the mercury that bioaccumulates in fish tissue is methylated. Numerous factors in can influence the bioaccumulation of mercury in aquatic biota. These include the acidity of the water (pH), length of the aquatic food chain, temperature and dissolved organic material. Physical and chemical characteristics of a watershed, such as soil type and erosion, affect the amount of mercury that is transported from soils to water bodies. Interrelationships between these factors are poorly understood, however, and there is no single factor (including pH) that has been correlated with mercury bioaccumulation in all cases examined.

Mercury accumulates in an organism when the rate of uptake exceeds the rate of elimination. Although all forms of mercury can accumulate to some degree, methylmercury accumulates to a greater extent than other forms of mercury. Inorganic mercury can also be absorbed but is generally taken up at a slower rate and with lower efficiency than is methylmercury. Elimination of methylmercury takes place very slowly resulting in tissue half-lives (i.e., the time in which half of the mercury in the tissue is eliminated) ranging from months to years. Elimination of methylmercury from fish is so slow that long-term reductions of mercury concentrations in fish are often due mainly to growth of the fish. By comparison, other mercury compounds are eliminated relatively quickly resulting in reduced levels of accumulation.

Methylmercury production and accumulation in the freshwater ecosystem is an efficient process for accumulating mercury which can then be ingested by fish-eating (piscivores) birds, animals and people. In addition, methylmercury generally comprises a relatively greater percentage of the total mercury content at higher trophic levels. Accordingly, mercury exposure and accumulation is of particular concern for animals at the highest trophic levels in aquatic food webs and for animals and humans that feed on these organisms.

Human Exposure Pathways and Health Effects

Humans are most likely to be exposed to methylmercury through fish consumption. Exposure may occur through other routes as well (e.g., the ingestion of methylmercury-contaminated drinking water and food sources other than fish, and dermal uptake through soil and water); however, the fish consumption pathway dominates these other pathways for people who eat fish.

There is a great deal of variability among individuals who eat fish with respect to food sources and fish consumption rates. As a result, there is a great deal of variability in exposure to methylmercury in these populations. The presence of methylmercury in fish is, in part, the result of anthropogenic mercury releases from industrial and combustion sources. As a consequence of human consumption of the affected fish, there is an incremental increase in exposure to methylmercury.

Mercury is a known human toxicant. Clinically observable neurotoxicity has been observed following exposure to high amounts of mercury (for example, "Mad Hatters' Disease"). Consumption of highly contaminated food also has produced overt mercury neurotoxicity. Studies in humans and in experimental animals are described in Volume V of the Mercury Study Report to Congress. Generally, the most subtle indicators of methylmercury toxicity are neurological changes. The neurotoxic effects include subtle decrements in motor skills and sensory ability at comparatively low doses to tremors, inability to walk, convulsions and death at extremely high exposures.

Environmental Impacts

Adverse effects of mercury on fish include death, reduced reproductive success, impaired growth and development and behavioral abnormalities. Exposure to mercury can also cause adverse effects in plants, birds and mammals. Reproductive effects are the primary concern for mercury poisoning and can occur at dietary concentrations well below those which cause overt toxicity. Effects of mercury on birds and mammals include death, reduced reproductive success, impaired growth and development and behavioral abnormalities. Sublethal effects of mercury on birds and mammals include liver damage, kidney damage, and neurobehavioral effects. Effects of mercury on plants include death and sublethal effects. Sublethal effects on aquatic plants can include plant senescence, growth inhibition and decreased chlorophyll content. Sublethal effects on terrestrial plants can include decreased growth, leaf injury, root damage, and inhibited root growth and function.

Concentrations of mercury in the tissues of wildlife species have been reported at levels associated with adverse effects. Toxic effects on piscivorous avian and mammalian wildlife due to the consumption of contaminated fish have been observed in association with point source releases of mercury to the environment. However, field data are insufficient to conclude whether wildlife has suffered adverse effects due to airborne mercury.

Mercury Levels in the United States

Based on 1996 data compiled by U.S. EPA's Office of Water, advisories have been issued in 39 states that warn against the consumption of certain amounts and species of fish that are contaminated with mercury. Ten states have statewide advisories (i.e., advisories posted on every freshwater body in that state). These advisories are based on the results of sampling surveys that measure mercury levels in representative fish species collected from water bodies. The advisories are intended for people who catch and eat fish from those waterbodies.

Table 2-1 presents the range of average mercury concentrations in parts per million (ppm) in major fish species throughout the U.S. (i.e., these are ranges of averages values measured by State agencies across the U.S., not ranges of individual sample values used to calculate the means). This information is based on data which represent the results of fish samples from the District of Columbia and 36 states.

The fish samples were analyzed during the period from 1990 through 1995. The three species of bottom feeders categorized in the table are carp, white sucker and channel catfish. Largemouth bass, smallmouth bass, walleye, brown trout and northern pike represent the major predatory fish species.

3. FINDINGS OF THE MERCURY STUDY REPORT TO CONGRESS

Sources Contributing to Mercury in the Environment

In the CAA, Congress directed U.S. EPA to examine sources of mercury emissions, including electric utility steam generating units, municipal waste combustion units and other sources, including area sources. The U.S. EPA interpreted the phrase "... and other sources..." to mean that a comprehensive examination of mercury sources should be made and to the extent data were available, air emissions should be quantified. Volume II of this Report describes in some detail various source categories that emit mercury. In many cases, a particular source category is identified as having the potential to emit mercury, but data are not available to assign a quantitative estimate of emissions. The U.S. EPA's intent was to identify as many sources of mercury emissions to the air as possible and to quantify those emissions where possible.

The mercury emissions data that are available vary considerably in quantity and quality among different source types. Not surprisingly, the best available data are for source categories that U.S. EPA has examined in the past or is currently studying.

Sources of mercury emissions in the United States are ubiquitous. To characterize these emissions, the types are defined in the following way:

- *Natural mercury emissions* -- the mobilization or release of geologically bound mercury by natural processes, with mass transfer of mercury to the atmosphere;

- *Anthropogenic mercury emissions* -- the mobilization or release of geologically bound mercury by human activities, with mass transfer of mercury to the atmosphere; or

- *Re-emitted mercury* -- the mass transfer of mercury to the atmosphere by biologic and geologic processes drawing on a pool of mercury that was deposited to the earth's surface after initial mobilization by either anthropogenic or natural activities.

Contemporary anthropogenic emissions of mercury are only one component of the global mercury cycle. Releases from human activities today are adding to the mercury reservoirs that already exist in land, water, and air, both naturally and as a result of previous human activities. Given the present understanding of the global mercury cycle, the flux of mercury from the atmosphere to land or water at any one location is comprised of contributions from the following:

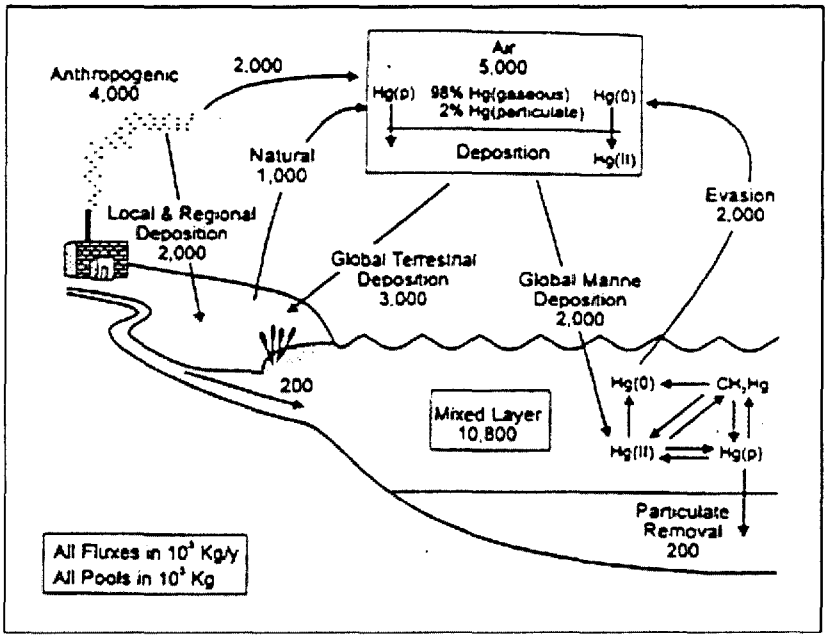
- The natural global cycle,
- The global cycle perturbed by human activities,
- Regional sources, and
- Local sources.

Local sources could also include direct water discharges in addition to air emissions. Past uses of mercury, such as fungicide application to crops are also a component of the present mercury burden in the environment.

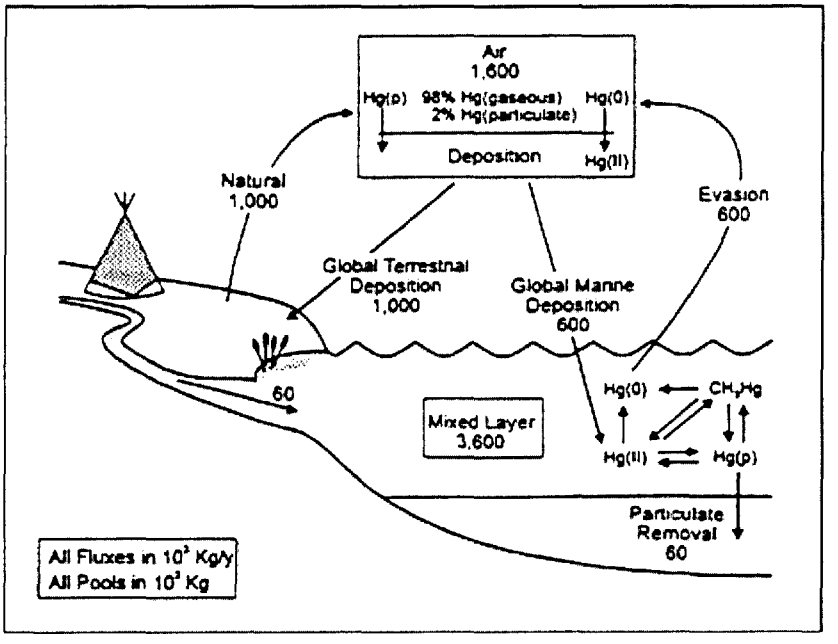
Understanding of the global mercury cycle (shown schematically in Figure 3-1) has improved significantly with continuing study of source emissions, mercury fluxes to the earth's surface, and the

Figure 3-1
Comparison of Estimated Current and Pre-Industrial Mercury Budgets and Fluxes

Current Mercury Budgets and Fluxes



Pre-Industrial Mercury Budgets and Fluxes



Source: Adapted from Mason, R.P. Fitzgerald, W.F. and Morel, M.M. 1994. The Biogeochemical Cycling of Elemental Mercury: Anthropogenic Influences. *Geochem. Cosmochim. Acta*, 58(15):3191-3198.

magnitude of mercury reservoirs that have accumulated in soils, watersheds and ocean waters. Although considerable uncertainty still exists, it has become increasingly evident that anthropogenic emissions of mercury to the air rival or exceed natural inputs. Recent estimates place the annual amounts of mercury released into the air by human activities at between 50 and 75 percent of the total yearly input to the atmosphere from all sources. Recycling of mercury at the earth's surface, especially from the oceans, extends the influence and active lifetime of anthropogenic mercury releases.

A better understanding of the relative contribution of mercury from anthropogenic sources is also limited by substantial remaining uncertainties regarding the level of natural emissions as well as the amount and original source of mercury that is re-emitted to the atmosphere from soils, watersheds, and ocean waters. Recent estimates indicate that of the approximately 200,000 tons of mercury emitted to the atmosphere since 1890, about 95 percent resides in terrestrial soils, about 3 percent in the ocean surface waters, and 2 percent in the atmosphere. More study is needed before it is possible to accurately differentiate between natural emissions from these soils, watersheds and ocean water and from re-emissions of mercury which originated from anthropogenic sources. For instance, approximately one-third of total current global mercury emissions are thought to cycle from the oceans to the atmosphere and back again to the oceans, but a major fraction of the emissions from oceans consists of recycled anthropogenic mercury. According to the Expert Panel on Mercury Atmospheric Processes[2] 20 to 30 percent of the oceanic emission is from mercury originally mobilized by natural sources. Similarly, a potentially large fraction of terrestrial and vegetative emissions consists of recycled mercury from previously deposited anthropogenic and natural emissions.

Comparisons of contemporary (within the last 15-20 years) measurements and historical records indicate that the total global atmospheric mercury burden has increased since the beginning of the industrialized period by a factor of between two and five (see Figure 3-1). It is uncertain, however, whether overall atmospheric mercury levels are currently increasing, decreasing or remaining stable. Measurements over remote areas in the Atlantic Ocean show increasing levels up until 1990 and a decrease for the period 1990-1994. At some locations in the upper midwest of the U.S., measurements of deposition rates suggest decreased deposition at some locations. This decrease has been attributed to control of mercury emissions from local or regional sources. However, measurements at remote sites in northern Canada and Alaska show deposition rates that continue to increase. Since these remote sites are subject to global long-range sources rather than regional sources, these measurements may indicate that the global atmospheric burden of mercury is still increasing.

Although the estimated residence time of elemental mercury in the atmosphere is about 1 year, the equilibrium between the atmosphere and ocean waters results in a longer time period needed for overall change to take place in the size of the global reservoir. Therefore, by substantially increasing the size of the oceanic mercury pool, anthropogenic sources have introduced long term perturbations into the global mercury cycle. Fitzgerald and Mason[3] estimate that if all anthropogenic emissions were ceased, it would take about 15 years for mercury reservoirs in the oceans and the atmosphere to return to pre-industrial conditions. The Science Advisory Board, in its review of this study concluded that it could take significantly longer. There is scientific agreement however, that the slow release of mercury from

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[2]Expert Panel on Mercury Atmospheric Processes. September 1994. *Mercury Atmospheric Processes: A Synthesis Report.* Electric Power Research Institute. Report No. TR-104214.

[3]Fitzgerald, W. F., and R. P. Mason. 1996. The Global Mercury Cycle: Oceanic and Anthropogenic Aspects. Pp. 185-108 in Baeyens, W., R. Ebinghaus, and O. Vasiliev, eds., Global and Regional Mercury Cycles: Sources, Fluxes, and Mass Balances.

terrestrial sinks to freshwater and coastal waters will persist for a long time, probably decades, which effectively increases the length of time anthropogenic emissions would impact the environment. This is particularly significant given that the surface soils contain most of the pollution-derived mercury of the industrial period. As a result, it is uncertain at this time how long it would take after reductions in anthropogenic emissions for mercury levels in the global environment, including fish levels, to return to true background levels.

Because of the current scientific understanding of the environmental fate and transport of this pollutant, it is not possible to quantify the contribution of U.S. anthropogenic emissions relative to other sources of mercury, including natural sources and re-emissions from the global pool, on methylmercury levels in seafood and freshwater fish consumed by the U.S. population. Consequently, the U.S. EPA is unable to predict at this time how much, and over what time period, methylmercury concentrations in fish would decline as a result of actions to control U.S. anthropogenic emissions. This is an area of ongoing study.

Inventory Approach and Uncertainties

Given the considerable uncertainties regarding the levels of natural and re-emitted mercury emissions, the emissions inventory focused only on the nature and magnitude of mercury emissions from current anthropogenic sources. The U.S. EPA recognizes, however, that an assessment of the relative public health and environmental impact that can be attributed to current anthropogenic emissions is greatly complicated by both natural mercury emissions, previous emissions of mercury that have subsequently deposited and other sources such as water discharges and other previous uses (e.g., fungicide application). Further study is needed to determine the importance of natural and re-emitted mercury, and the contribution of water discharges relative to atmospheric deposition. Based on estimates of the total annual global input to the atmosphere from all sources (i.e, 5000 Mg from anthropogenic, natural, and oceanic emissions as illustrated by Figure 3-1), U.S. sources are estimated to contribute about 3 percent, based on 1995 emissions estimates as described below.

For most anthropogenic source categories, an emission factor-based approach was used to develop both facility-specific estimates for modeling purposes and nationwide emission estimates. This approach requires an emission factor, which is a ratio of the mass of mercury emitted to a measure of source activity. It also requires an estimate of the annual nationwide source activity level. Examples of measures of source activity include total heat input for fossil fuel combustion and total raw material used or product generated for industrial processes. Emission factors are generated from emission test data, from engineering analyses based on mass balance techniques, or from transfer of information from comparable emission sources. Emission factors reflect the "typical control" achieved by the air pollution control measures applied across the population of sources within a source category.

The emission factor-based approach does not generate exact emission estimates. Uncertainties are introduced in the estimation of emission factors, control efficiencies and the activity level measures. Ideally, emission factors are based on a substantial quantity of data from sources that represent the source category population. For trace pollutants like mercury, however, emission factors are frequently based on limited data that may not have been collected from representative sources. Changes in processes or emission measurement techniques over time may also result in biased emission factors. Emission control estimates are also generally based on limited data; as such, these estimates are imprecise and may be biased. Further uncertainty in the emission estimates is added by the sources of information used on source activity levels, which vary in reliability.

Current emissions of mercury from manufacturing sources are generally low compared to combustion sources (with the exception of chlor-alkali plants using the mercury cell process and portland cement manufacturing plants). The emissions of mercury are more likely to occur when the product (e.g., lamps, thermostats) is broken or discarded. Therefore, in terms of emission trends, one would expect that if the future consumption of mercury remains consistent with the 1996 consumption rate, emissions from most manufacturing sources would remain about the same.

Secondary production of mercury (i.e., recovering mercury from waste products) has increased significantly over the past few years. While 372 Mg of mercury were used in industrial processes in 1996, 446 Mg were produced by secondary mercury producers and an additional 340 Mg were imported. This is a two-fold increase since 1991. The number of secondary mercury producers is expected to increase as more facilities open to recover mercury from fluorescent lamps and other mercury-containing products (e.g., thermostats). As a result there is potential for mercury emissions from this source category to increase.

The largest identified source of mercury emissions during 1994-1995 is fossil fuel combustion by utility boilers, particularly coal combustion. Future trends in mercury emissions from this source category are largely dependent on both the nation's future energy needs and the fuel chosen to meet those needs. Another factor is the nature of actions the utility industry may take in the future to meet other air quality requirements under the Clean Air Act (e.g., national ambient air quality standards for ozone and particulate matter).

Two other significant sources of mercury emissions currently are municipal waste combustors and medical waste incinerators. Emissions from these source categories have declined considerably since 1990 on account of plant closures (for medical waste incinerators) and reduction in the mercury content of the waste stream (municipal waste combustors). Mercury emissions from both of these source types will decline even further by the year 2000 due to regulatory action the U.S. EPA is taking under the statutory authority of section 129 of the CAA. The U.S. EPA has finalized rules for municipal waste combustors and medical waste incinerators that will, when fully implemented, reduce mercury emissions from both of these source categories by an additional 90 percent over 1995 levels. In addition to this federal action, a number of states (including Minnesota, Florida and New Jersey) have implemented mandatory recycling programs to reduce mercury-containing waste, and some states have regulations that impose emission limits that are lower than the federal regulation. These factors will reduce national mercury emissions from these source categories even further.

Trends in Mercury Use

Data on industrial demand for mercury show a general decline in domestic mercury use since demand peaked in 1964. Domestic demand fell by 74 percent between 1980 and 1993, and by more than 75 percent between 1988 and 1996. The rate of decline, however, has slowed since 1990. Further evidence of the declining need for mercury in the U.S. is provided by the general decline in imports since 1988 and the fact that exports have exceeded imports since at least 1989. Federal mercury sales steadily increased from 1988 to 1993, reaching a peak of 97 percent of the domestic demand. However, in July 1994, DLA suspended future sales of mercury from the Department of Defense stockpile until the environmental implications of these sales are addressed. In addition, in past years, DLA sold mercury accumulated and held by the Department of Energy, which is also considered excess to government needs. DLA suspended these mercury sales in July 1993 for an indefinite period in order to concentrate

on selling material from its own mercury stockpile. These suspensions caused federal sales to rapidly decrease to 18 percent of domestic demand in 1994 and to zero since 1995[4].

For industrial or manufacturing sources that use mercury in products or processes, the overall consumption of mercury is generally declining. Industrial consumption of mercury has declined by about 75 percent between 1988 (1503 Mg) and 1996 (372 Mg). Much of this decline can be attributed to the elimination of mercury as a paint additive and the reduction of mercury in batteries. Use of mercury by other source categories remained about the same between 1988 and 1996.

In general, these data suggest that industrial manufacturers that use mercury are shifting away from mercury except for uses for which mercury is considered essential. This shift is believed to be largely the result of Federal bans on mercury additives in paint and pesticides; industry efforts to reduce mercury in batteries; increasing state regulation of mercury emissions sources and mercury in products; and state-mandated recycling programs. A number of Federal activities are also underway to investigate pollution prevention measures and control techniques for a number of sources categories (see Volume VIII of this Report to Congress).

Assessment Approach for Fate and Transport of Mercury

Study Design of the Fate and Transport Analysis

This analysis relied heavily on computer modeling to describe the environmental fate of emitted mercury because no monitoring data have been identified that conclusively demonstrate or refute a relationship between any of the individual anthropogenic sources in the emissions inventory and increased mercury concentrations in environmental media or biota. To determine if there is a connection between the above sources and increased environmental mercury concentrations, three different models were utilized. Volume III of this Report describes in detail the justification for choices of values for model parameters.

Given the scientific uncertainties associated with environmental mercury, U.S. EPA decided that it was most appropriate to examine the environmental fate of mercury at generalized, rather than specific, sites. A single air model which was capable of modeling both the local as well as regional fate of mercury was not identified. This resulted in the use of two air models: the Regional Lagrangian Model of Air Pollution (RELMAP), for assessing regional scale atmospheric transport, and the Industrial Source Code model (ISC3), for local scale analyses (i.e., within 50 km of a source). To examine the fate of mercury in terrestrial and aquatic environments, U.S. EPA modified an existing generalized watershed and water body fate model. The modified model is identified as IEM-2M. Each of the fate and transport models used in the analysis is summarized in Table 3-2.

[4]Plachy, Jozef, 1997. Mineral Industry Surveys: Mercury Annual Review 1996. Reston, VA. June 1997.

These estimates were used as inputs to the IEM-2M aquatic and terrestrial fate models at the hypothetical western and eastern U.S. sites.

In the third step of this risk assessment, IEM-2M was utilized to predict the different chemical species of mercury and their concentrations in watershed soils, the water column and sediments of the hypothetical lake, as well as in terrestrial and aquatic organisms. Soil concentrations are used along with vapor concentrations, deposition rates and biotransfer factors to estimate concentrations in various plants. These are used, in turn, along with other biotransfer factors to estimate concentrations in animals. Methylmercury (MHg) concentrations in fish are derived from dissolved MHg water concentrations using bioaccumulation factors (BAF). The BAF accounts for mercury accumulation in organisms that comprise the food web. The BAFs used in this analysis were calculated from existing field data.

A significant input to the IEM-2M model was the estimate of existing mercury concentrations in the environment. To determine existing background concentrations in soil, water, and sediments, U.S. EPA estimated current "background" atmospheric concentrations and deposition rates to the hypothetical western and eastern sites. Each site was then modeled using IEM-2M until equilibrium was achieved with the specified atmospheric background conditions. At both hypothetical sites, the fate of deposited mercury was examined in three different settings: rural (agricultural), lacustrine (around a water body), and urban.
The resulting predictions of mercury concentrations in soil, water, and biota were then used to evaluate mercury exposures to humans and wildlife as described in Volumes IV and V of this Report.

Figure 3-2 illustrates the how the various fate models were integrated.

Long-Range Transport Analysis

The long range transport modeling predicts the regional and national deposition of mercury across the continental U.S. Details of several studies which demonstrate the long range transport of mercury are presented in Volume III. In this analysis, the long range transport of mercury was modeled using site-specific, anthropogenic emission source data (presented in Volume II of this Report) to generate average annual atmospheric mercury concentrations and deposition values across the continental U.S. The Regional Lagrangian Model of Air Pollution (RELMAP) was the model selected for this analysis.

From the RELMAP analysis and a review of field measurement studies, it is concluded that mercury deposition appears to be ubiquitous across the continental U.S., and at, or above, detection limits when measured with current analytic methods. The southern Great Lakes and Ohio River Valley, the Northeast, and scattered areas in the South (particularly in the Miami and Tampa areas) are predicted to have the highest annual rate of deposition of total mercury (above the levels predicted at the 90th percentile). Figure 3-3 illustrates the pattern of mercury deposition across the U.S. This figure also illustrates the boundaries of the RELMAP modeling domain. Measured deposition data are limited, but are available for certain geographic regions. The data that are available corroborate the RELMAP modeling predictions for specific areas. These comparisons are discussed in detail in Volume III.

A wide range of mercury deposition rates is predicted across the continental U.S. The highest predicted rates (i.e., above 90th percentile) are about 20 times higher than the lowest predicted rates (i.e., below the 10th percentile).

The three principal factors that contribute to these modeled and observed deposition patterns are:

- the emission source locations;

Figure 3-2
Fate, Transport and Expsoure Modeling Conducted in the Combined ISC3 and RELMAP Local Impact Analysis

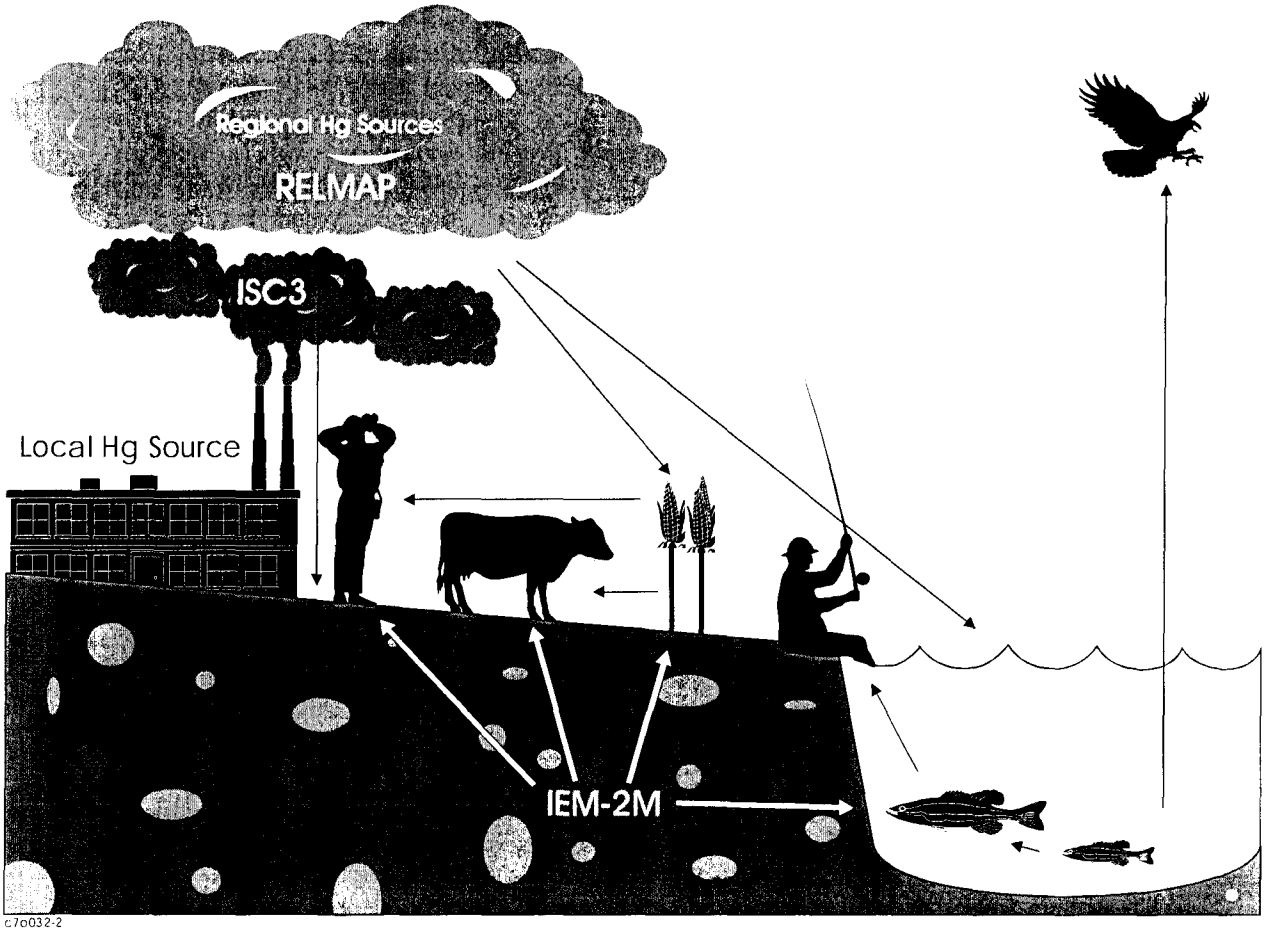
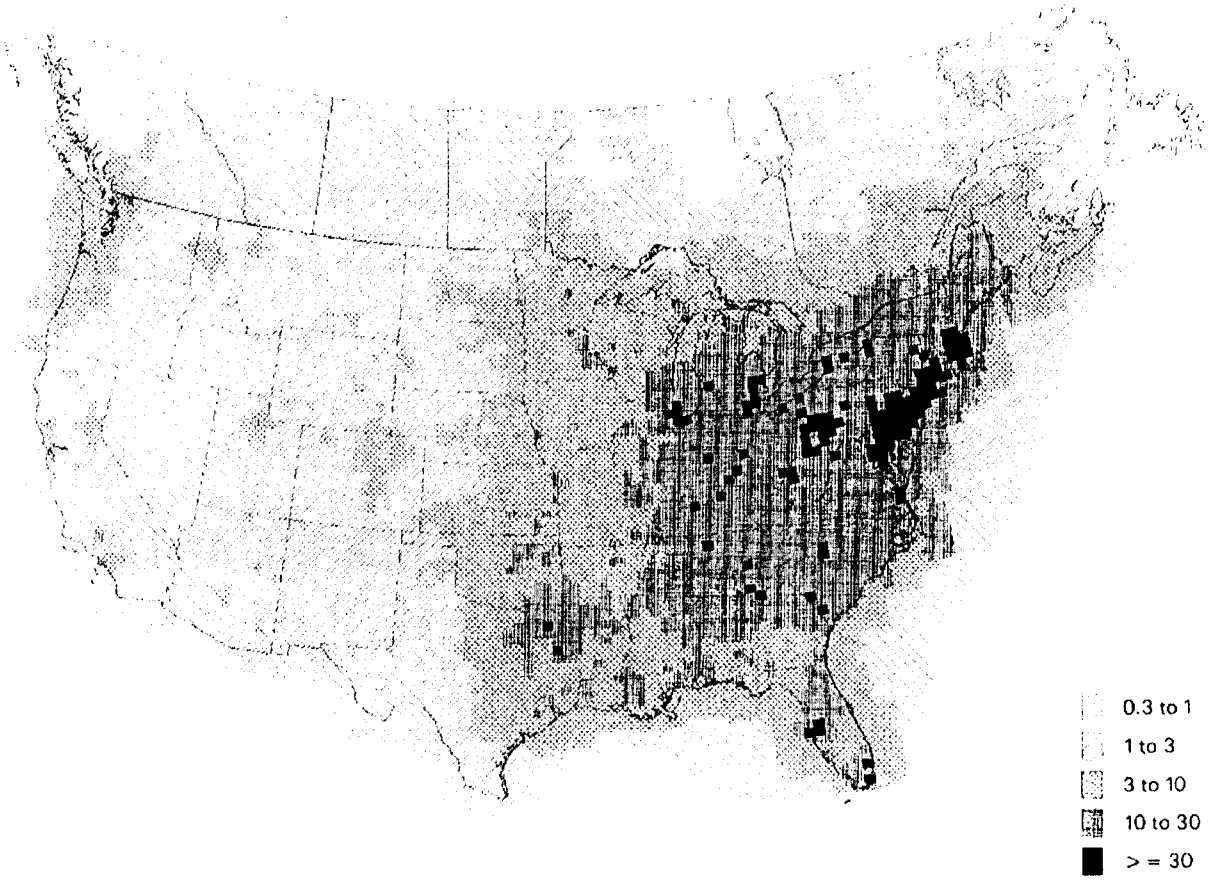


Figure 3-3
Total Simulated Wet + Dry Deposition of Mercury in All Forms
Units: $\mu g/m^2$



- the amount of divalent and particulate mercury emitted or formed in the atmosphere; and
- climate and meteorology.

A facility located in a humid climate is predicted to have a higher annual rate of mercury deposition than a facility located in an arid climate.

The critical variables within the model are:

- the estimated washout ratios of elemental and divalent mercury; and
- the annual amount of precipitation.

Precipitation is important because it removes various forms of mercury from the atmosphere and deposits them to the surface of the earth.

Mass Balances of Mercury within the Long-range Model Domain

The chemical form of emitted mercury is a critical factor in its fate, transport and toxicity in the environment. With the exception of hazardous waste incinerators, for which there are site-specific speciated data, mercury emissions are reported as total mercury in all forms. The form distributions, or speciation factors, define the estimated fraction of mercury emitted as elemental mercury (Hg^0), divalent mercury (Hg^{2+}), or mercury associated with particulates (Hg_p). These speciation factors were adopted from Peterson et al.[5] with adjustments made to reflect the types of air pollution control equipment known to be installed at individual industrial plants. There is considerable uncertainty about the speciation factors for some industrial sources. A wide variety of alternate speciation scenarios have been investigated to measure the sensitivity of the RELMAP results to this uncertainty[6,7]. The results show that the total simulated wet and dry deposition of mercury to the continental U. S. is strongly and positively correlated to the fraction of mercury emitted as Hg^{2+} and Hg_p for all major source types. The speciation factors used in the RELMAP modeling for this Report are discussed in Volume III.

The results of the RELMAP modeling using these assumed speciation factors are described below. The general mass balance of elemental mercury gas, divalent mercury gas, and particle-bound mercury from the RELMAP simulation results using specified speciation profiles are shown in Table 3-3. Using the meteorologic data from the year 1989, the mass balance shows a total of 141.8 metric tons of mercury emitted to the atmosphere from anthropogenic sources. (This simulated emission total differs from the national totals indicated in Volume II since the states of Alaska and Hawaii are not within the model domain.) The simulation indicates that 47.6 metric tons of anthropogenic mercury emissions are deposited within the model domain and 0.4 metric tons remain in the air within the model domain at the end of the simulation. The remainder, about 93.8 metric tons, is transported outside the model domain and probably diffuses into the global atmospheric reservoir.

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[5]Petersen, G., Å. Iverfeldt and J. Munthe. (1995) Atmospheric mercury species over Central and Northern Europe. Model calculations and comparison with observations from the Nordic Air and Precipitation Network for 1987 and 1988. Atmospheric Environment 29:47-68.

[6]Bullock, Jr., O. R., W. G. Benjey and M. H. Keating. (1997) Modeling of regional scale atmospheric mercury transport and deposition using RELMAP. *Atmospheric Deposition of Contaminants to the Great Lakes and Coastal Waters: Joel E. Baker, Ed.* pp.323-347. SETAC Press, Pensacola, Florida.

[7]Bullock, Jr., O. R., K. A. Brehme and G. R. Mapp. (1997) Lagrangian modeling of mercury air emission, transport and deposition: An analysis of model sensitivity to emissions uncertainty. *Special Issue on Mercury as a Global Pollutant: Science of the Total Environment,* in press.

The simulation also indicates that 32.0 metric tons of mercury are deposited within the model domain from this global atmospheric reservoir, suggesting that about three times as much mercury is being added to the global reservoir from U.S. emissions as is being deposited from it. The total amount of mercury deposited in the model domain annually from U.S. anthropogenic emissions and from the global background concentration is estimated to be 79.6 metric tons, of which approximately three-fifths is emitted by anthropogenic sources in the lower 48 United States.

Of the total anthropogenic mercury mass deposited to the surface in the model domain, 77% is estimated by the RELMAP to come from Hg^{2+} emissions, 21% from Hg_p emissions and 2% from Hg^0 emissions. When the deposition of Hg^0 from the global background is considered in addition to anthropogenic sources in the lower 48 states, the species fractions of total deposition become 46% Hg^{2+}, 41% Hg^0 and 13% Hg_p. The vast majority of mercury already in the global atmosphere is in the form of Hg^0 and, in general, the anthropogenic Hg^0 emissions do not greatly elevate the Hg^0 air concentration over the global background value. Although Hg^0 is removed from the atmosphere very slowly, the global background reservoir is large and total deposition from it is significant. It should be noted that dry deposition of Hg^0 is thought to be significant only at very elevated concentrations and has not been included in the RELMAP simulations. Wet deposition is the only major pathway for removal of Hg^0 from the atmosphere. This removal pathway simulated by the RELMAP involves oxidation of mercury by ozone in an aqueous solution; thus, the Hg^0 that is extracted from the atmosphere by the modeled precipitation process would actually be deposited primarily in the form of Hg^{2+}.

Table 3-3
Modeled Mercury Mass Budget in Metric Tons for 1994-1995
Using the Specified Speciation Profiles and 1989 Meteorology

Source/Fate	Hg^{0a}	Hg^{2+b}	Hg_p^{c}	Total Mercury
Total U.S. anthropogenic emissions	63.5	52.3	26.0	141.8
Mass advected from model domain	62.3	15.5	16.0	93.8
Dry deposited anthropogenic emissions	0.0	22.9	0.5	23.4
Wet deposited anthropogenic emissions	0.9	13.8	9.5	24.2
Remaining in air at end of simulation	0.4	<0.1	<0.1	0.4
Total deposited anthropogenic emissions	0.9	36.8	10.0	47.6
Deposited from background Hg^0	32.0	0.0	0.0	32.0
Mercury deposited from all sources	32.9	36.8	10.0	79.6

(All figures rounded to the nearest tenth of a metric ton)

[a] Hg^0 = Elemental Mercury
[b] Hg^{2+} = Divalent Vapor-phase Mercury
[c] Hg_p = Particle-Bound/Mercury

Of the 63.5 metric tons of anthropogenic Hg^0 emitted in the lower 48 states, only 0.9 tons (1.4%) is deposited within the model domain, while of the 52.3 metric tons of Hg^{2+} emitted, about 36.8 tons (70.4%) is deposited. Ninety-eight percent of the deposited anthropogenic mercury was emitted in the form of Hg^{2+} or Hg_p. Thus, a strong argument can be made that the combined Hg^{2+} and Hg_p component of anthropogenic mercury emissions can be used as an indicator of eventual deposition of those emissions to the lower 48 states and surrounding areas. The emission inventory and chemical/physical

speciations profiles indicate that of all combined Hg^{2+} and Hg_P emissions in 1994-1995, about 29% is from electric utility boilers, 25% is from municipal waste combustion, 18% is from medical waste incineration, 16% is from commercial and industrial boilers, and 12% is from all other modeled sources.

Limitations of the Long-Range Transport (RELMAP) Analysis

There are a number of uncertainties with the RELMAP analysis. These have to do to a large degree with the current state-of-the-science concerning atmospheric chemistry and speciation profiles of mercury emissions. Some of the most important limitations are listed below.

- Comprehensive emissions data for a number anthropogenic and natural sources are not available. This reflects the current developmental nature of emission speciation methods, resulting in few data on the various species of mercury and proportions of vapor and solid forms emitted. Both elemental and divalent mercury species as well as gaseous and particulate forms are known to be emitted from point and area sources.

- Atmospheric chemistry data are incomplete. Some atmospheric reactions of mercury, such as the oxidation of elemental mercury to divalent mercury in cloud water droplets have been reported. Other chemical reactions in the atmosphere that may reduce divalent species to elemental mercury have not been reported.

- There is inadequate information on the atmospheric processes that affect wet and dry deposition of mercury. Atmospheric particulate forms and divalent species of mercury are thought to wet and dry deposit more rapidly than elemental mercury; however, the relative rates of deposition are uncertain. There is no validated air pollution model that estimates wet and dry deposition of vapor-phase compounds close to the emission source. In addition, there is uncertainty regarding the revolatilization of deposited mercury.

Analysis of the Local Atmospheric Fate of Mercury

An analysis of the local atmospheric fate of mercury (within 50 km) released from anthropogenic emission sources was undertaken using the ISC-3 model to estimate the impacts of mercury from selected, individual source types. The ISC-3 model was slightly modified to correspond more closely to the chemical properties of atmospheric mercury. This analysis addressed atmospheric mercury emissions from MWCs, coal- and oil-fired utility boilers, MWIs, and chlor-alkali plants. A model plant approach was utilized to develop facilities which represent actual sources from these four categories. The model plants were situated in hypothetical locations intended to simulate a site in either the western or eastern U.S.

The ISC-3 model was used in conjunction with the results from the RELMAP regional scale modeling in order to estimate the air concentrations and deposition rates for each hypothetical facility in each site. Once emitted from a source, mercury may be deposited to the ground via two main processes: wet and dry deposition. Wet deposition refers to the mass transfer of dissolved gaseous or suspended particulate mercury species from the atmosphere to the earth's surface by precipitation, while dry deposition refers to such mass transfer in the absence of precipitation.

The model parameters exerting the most influence on the deposition rates are these:

- total mercury emission rate (grams/second);
- assumptions regarding speciation of the total mercury;
- vapor/particle phase partition estimate;
- stack height for the plant; and
- exit gas velocity.

Combined Results of Local and Regional Scale Analyses

The results of the local scale ISC-3 modeling and the regional scale RELMAP modeling were combined to predict air concentrations and deposition rates for each hypothetical facility in each site. The predicted air concentrations are typically dominated by the regional values, even for the watersheds relatively close to the facility. In general, the predicted average air concentrations are quite low. The only source class for which significantly elevated air concentrations are predicted is the chlor-alkali facility. This is due to a very low stack height coupled with a high assumed mercury emission rate. The low stack height results in predicted plumes that are close to the receptors considered, and so there is less dispersion of the plume compared to the other facilities.

In contrast to the predicted air concentrations, the annual deposition rates are *cumulative*; they represent the sum of any deposition that occurs during the year, and hence are not affected by long periods of little deposition. Further, the ISC3 model predicts that significant deposition events occur infrequently, and it is these relatively rare events that are responsible for the majority of the annual deposition rate. The percentage of mercury deposited within 50 km depends on two main factors: facility characteristics that influence effective stack height (stack height plus plume rise) and the fraction of mercury emissions that is divalent mercury. In most cases, the effective stack height affects only the air concentrations, and hence dry deposition.

For any site with appreciable precipitation, wet deposition can dominate the total deposition for receptors close to the source. Single wet deposition events can deposit 300 times more Hg than a high dry deposition event. These events are even rarer than significant dry deposition events because not only must the wind direction be within a few degrees of the receptor's direction, but precipitation must be occurring as well. The predicted dry deposition rates depend ultimately on the predicted air concentrations. For this reason, dry deposition accounts for most of the total deposition for the facility with the highest predicted air concentrations, the chlor-alkali plant.

In general, 7-45% of the total mercury emitted is predicted to deposit within 50 km at the eastern site in flat terrain, while 2-38% is predicted to deposit at the western site. (The ranges represent values from the different sources considered.) This implies that at least 55% of the total mercury emissions is transported more than 50 km from any of the sources considered, and is consistent with the RELMAP results that predict that mercury may be transported across considerable distances.

The differences between the results for the eastern and western sites are due primarily to the differences in the frequency and intensity of precipitation. At the eastern site, precipitation occurs about 12 % of the year, with about 5% of this precipitation of moderate intensity (0.11 to 0.30 in/hr). By comparison, at the western site, precipitation occurs about 3% of the year, with about 2% of the precipitation of moderate intensity.

Assessment of Watershed Fate

The atmospheric mercury concentrations and deposition rates estimated using the RELMAP and ISC3 were then used as inputs in the watershed model, IEM-2M, to derive calculations of mercury in watershed soils and surface waters. The soil and water concentrations, in turn, drive calculations of concentrations in the associated biota and fish, which humans and other animals are assumed to consume.

IEM-2M is composed of two integrated modules that simulate mercury fate using mass balance equations describing watershed soils and a shallow lake. The mass balances are performed for each mercury component, with internal transformation rates linking Hg^0, Hg^{2+}, and MeHg. Sources include wetfall and dryfall loadings of each component to watershed soils and to the water body. An additional source is diffusion of atmospheric Hg^0 vapor to watershed soils and the water body. Sinks include leaching of each component from watershed soils, burial of each component from lake sediments, volatilization of Hg^0 and MeHg from the soil and water column, and advection of each component out of the lake.

The nature of this methodology is basically steady with respect to time and homogeneous with respect to space. While it tracks the buildup of soil and water concentrations over the years given a steady depositional load and long-term average hydrological behavior, it does not respond to unsteady loading or meteorological events. There are, thus, limitations on the analysis and interpretations imposed by these simplifications. The model's calculations of average water body concentrations are less reliable for unsteady environments, such as streams, than for more steady environments, such as lakes.

The BAFs were used to estimate fish methylmercury concentrations based on measured concentrations of dissolved methylmercury in the water column. The distribution of the BAFs (Appendix D, Vol. III) was designed to estimate an average concentration of methylmercury in fish of a given trophic level from an average concentration of dissolved methylmercury in the epilimnion for a (single) randomly-selected lake in the continental U.S. The large amount of variability evidenced by the data and reflected in the output distributions arises from several sources, which were not quantified. Much of this variability depends on fish age, model uncertainty, and possibly the use of unrepresentative water column methylmercury measurements in the calculation of the BAFs.

Results of the Watershed Fate and Transport Analysis

For all facilities the contribution of the local source decreases as the distance from the facility increases. With the exception of the chlor-alkali plant, the facilities are generally predicted to contribute less than 50% to the total watershed soil concentration, with RELMAP (representing the regional anthropogenic sources) contributing up to 15% for the RELMAP 50th percentiles, and up to 60% for the RELMAP 90th percentiles.

The results for the MeHg water concentrations and trophic level 4 fish concentrations show a slightly higher contribution from the local sources. While the fractions are similar to those for watershed soil since the watershed serves as a mercury source for the waterbody, these values are slightly higher due to the direct deposition onto the waterbody.

The predicted fruit, leafy vegetable, and beef concentrations are generally dominated by the background values. For plants, this is because these products are assumed to take up most of the mercury from the air, and the local source usually does not impact the local air concentrations significantly. The exception is the chlor-alkali plant, for which the low stack results in higher mercury

air concentrations. The results for the beef concentrations are similar; however, there is a slightly higher contribution from the local source because the cattle are exposed through the ingestion of soil.

IEM-2M Model Sensitivity

For a specific atmospheric deposition rate, mercury concentrations in watersheds and water bodies can vary significantly. Several intrinsic and extrinsic watershed and water body characteristics influence the mercury concentrations in soil, water, and fish. These should cause significant variability in mercury concentrations between regions and among individual lakes within a region.

Mercury concentrations in watershed soils are strongly influenced by atmospheric loading and soil loss processes. The influence of plant canopy and roots in mediating both the loading to the soil and the loss from the soil is not well characterized at present, although published studies indicate its potential importance. Reduction of HgII in the upper soil layer appears to control the volatile loss of mercury, and variations in this reaction can cause significant variations in soil mercury levels. The factors controlling mercury reduction are not well characterized at present. Soil erosion from a watershed can vary more than 3 orders of magnitude depending on rainfall patterns, soil type, topography, and plant cover. High levels of soil erosion should significantly diminish soil mercury concentrations. Runoff and leaching are not expected to affect soil mercury concentrations significantly.

Total mercury concentrations in a water body are strongly influenced by atmospheric loading and, for drainage lakes, by watershed loading. Variations in watershed size and erosion rates can cause significant variability in lake mercury levels. Hydraulic residence time, the water body volume divided by total flow, affects the maximum possible level of total water column mercury for a given loading rate. Parameters controlling mercury loss through volatilization and net settling can also cause significant variations among lakes. Mercury loss through settling is affected by *in-situ* productivity, by the supply of solids from the watershed, and by the solids-water partition coefficient. DOC concentrations can significantly affect partitioning, and thus overall mercury levels. Mercury loss through volatilization is controlled by the reduction rate, which is a function of sunlight and water clarity. Reduction may also be controlled by pH, with lower pH values inhibiting this reduction, leading to higher total mercury levels.

Fish mercury levels are strongly influenced by the same factors that control total mercury levels. In addition, fish concentrations are sensitive to methylation and demethylation in the water column and sediments. A set of water body characteristics appear to affect these reactions, including DOC, sediment TOC, sunlight, and water clarity. Variations in these properties can cause significant variations in fish concentrations among lakes. Other factors not examined here, such as anoxia and sulfate concentrations, can stimulate methylation and lead to elevated fish concentrations. Fish mercury levels are sensitive to factors that promote methylmercury mobility from the sediments to the water column; these factors include sediment DOC and sediment-pore water partition coefficients.

Limitations of the Local Scale and Watershed Analyses

There are limitations associated with the fate and transport analyses. These have to do to a large degree with the current state-of-the-science concerning mercury fate and transport in the terrestrial and aquatic environments and variability between waterbodies. Some of the most important limitations are listed below.

- There is a lack of information characterizing the movement of mercury from watershed soils to water bodies and the rates at which mercury converts from one chemical species to another. There appears to be a great deal of variability in these factors among watersheds.

- There are not conclusive data on the amount of and rates of mercury methylation in different types of water bodies. In addition, there is a lack of data on the transfer of mercury between environmental compartments and biologic compartments; for example, the link between the amount of mercury in the water body and the levels in fish appears to vary from water body to water body.

- There is a lack of adequate mercury measurement data near mercury sources. Measurement data are needed to assess how well the modeled data predict actual mercury concentrations in different environmental media at a variety of geographic locations. Missing data include measured mercury deposition rates and measured concentrations in the atmosphere, soils, water bodies and biota.

- The IEM-2M has not been validated with site-specific data. The model was benchmarked against the independently-derived R-MCM, which itself has been calibrated to several Wisconsin lakes. When driven by the same atmospheric loading and solids concentrations, IEM-2M predictions of mercury concentrations compare well with those calculated by R-MCM for a set of Wisconsin lakes.

Conclusions Regarding Mercury Fate and Transport in the Environment

The uncertainty inherent in the modeled estimates arises from many individual assumptions present within the three models. Because of these uncertainties, U.S. EPA interpreted the model results qualitatively rather than quantitatively as follows.

The analysis of mercury fate and transport, in conjunction with available scientific knowledge, supports a plausible link between mercury emissions from anthropogenic combustion and industrial sources and mercury concentrations in air, soil, water and sediments. The critical variables contributing to this linkage are these:

- the species of mercury that are emitted from the sources, with Hg^0 mostly contributing to concentrations in ambient air and Hg^{2+} mostly contributing to concentrations in soil, water and sediments;

- the overall amount of mercury emitted from a combustion source;

- the watershed soil loss rates, including reduction and erosion;

- the water body loss rates, including outflow, reduction, and settling; and

- the climate conditions.

In addition, the analysis of mercury fate and transport supports a plausible link between mercury emissions from anthropogenic combustion and industrial sources and methylmercury concentrations in freshwater fish. The critical variables contributing to this linkage are the following:

- the species of mercury that are emitted, with emitted divalent mercury mostly depositing into local watershed areas and, to a lesser extent the atmospheric conversion of elemental mercury to divalent species which are deposited over greater distances;

- the overall amount of mercury emitted from a source;

- the watershed soil loss rates, including reduction and erosion;

- Loon, Mink, Osprey
- Bald Eagle

Methylmercury exposures for the most exposed wildlife species (the kingfisher) may be up to two orders of magnitude higher than human exposures from contaminated freshwater fish (on a kilogram fish consumed per body weight basis). This assumes that the fish within different tropic levels of a given lake are contaminated with the same concentrations of methylmercury.

Human Health Effects of Methylmercury

Data in both humans and experimental animals show that all three forms of mercury evaluated in this Report (elemental, inorganic and methylmercury) can produce adverse health effects at sufficiently high doses. Human exposure to elemental mercury occurs in some occupations, and exposure to inorganic mercury can arise from mercury amalgams used in dental restorative materials (U.S. PHS, Environmental Health Policy Committee, 1995). People, however, are primarily exposed to methylmercury in fish. The focus of this assessment, therefore, is on methylmercury, which can produce a variety of adverse effects, depending on the dose and time of exposure.

Individual risk assessors for specific organizations may apply risk assessment differently. Identification of subpopulations of concern is one of the decisions in the risk assessment process. Because methylmercury is a neurotoxin (particularly to the developing nervous system), the fetus and young child are of particular interest. More than one approach to selection of the population at risk of adverse effect is feasible. The RfD of 0.1 μg/kg bw/day was based on neurotoxic effects of methylmercury to the developing nervous system. Because nervous system development continues into postnatal life the young child may also be a subpopulation of interest. If children are judged to be a subpopulation of concern, specific age-groups within this subpopulation may be judged to be of greater interest; e.g., birth through 4 years of age. Alternatively other risk assessors may prefer to consider all children (e.g., birth through 14 years of age) as a group when evaluating risk to children.

Methylmercury-induced neurotoxicity is the effect of greatest concern when exposure occurs to the developing fetus. The RfD is a dose of methylmercury that is protective of the developing fetal nervous system. Post-natal brain development continues well into childhood. Methylmercury exposure adversely affects a number of cellular events in the developing brain both in utero and post-natally. The post-natal age when development of various regions of the brain is completed varies, but development of many functions continues through the first four to six years of life. The RfD of 0.1 ug/kg-bw/day (protective of fetal brain development) is anticipated to be protective of brain development in the young child.

Toxicokinetics of Mercury

The toxicokinetics (i.e., absorption, distribution, metabolism, and excretion) of mercury is highly dependent on the form of mercury to which a receptor has been exposed.

The absorption of elemental mercury vapor occurs rapidly through the lungs, but it is poorly absorbed from the gastrointestinal tract. Once absorbed, elemental mercury is readily distributed throughout the body; it crosses both placental and blood-brain barriers. The distribution of absorbed elemental mercury is limited primarily by the oxidation of elemental mercury to the mercuric ion as the mercuric ion has a limited ability to cross the placental and blood-brain barriers. Once elemental mercury crosses these barriers and is oxidized to the mercuric ion, return to the general circulation is impeded, and mercury can be retained in brain tissue. Elemental mercury is eliminated from the body via urine, feces, exhaled air, sweat, and saliva. The pattern of excretion changes depending upon the extent the elemental mercury has been oxidized to mercuric mercury.

Absorption of inorganic mercury through the gastrointestinal tract varies with the particular mercuric salt involved; absorption decreases with decreasing solubility. Estimates of the percentage of inorganic mercury that is absorbed vary; as much as 20% may be absorbed. Inorganic mercury has a reduced capacity for penetrating the blood-brain or placental barriers. There is some evidence indicating that mercuric mercury in the body following oral exposures can be reduced to elemental mercury and excreted via exhaled air. Because of the relatively poor absorption of orally administered inorganic mercury, the majority of the ingested dose in humans is excreted through the feces.

Methylmercury is rapidly and extensively absorbed through the gastrointestinal tract. Absorption information following inhalation exposures is limited. This form of mercury is distributed throughout the body and easily penetrates the blood-brain and placental barriers in humans and animals. Methylmercury in the body is considered to be relatively stable and is only slowly demethylated to form mercuric mercury in rats. It is hypothesized that methylmercury metabolism may be related to a latent or silent period observed in epidemiological studies observed as a delay in the onset of specific adverse effects. Methylmercury has a relatively long biological half-life in humans; estimates range from 44 to 80 days. Excretion occurs via the feces, breast milk, and urine.

The most common biological samples analyzed for mercury are blood, urine and scalp hair. The methods most frequently used to determine the mercury levels in these sample types include atomic absorption spectrometry, neutron activation analysis, X-ray fluorescence and gas chromatography.

Two major epidemics of methylmercury poisoning through fish consumption have occurred. The best known of these two epidemics occurred among people and wildlife living near Minamata City on the shores of Minamata Bay, Kyushu, Japan. The source of methylmercury was a chemical factory that used mercury as a catalyst. A series of chemical analyses identified methylmercury in the factory waste sludge, which was drained into Minamata Bay. Once present in Minamata Bay, the methylmercury accumulated in the tissue of shellfish and fish that were subsequently consumed by wildlife and humans. Fish was a routine part of the diet in these populations. An average fish consumption was reported to be in excess of 300 g/day (reviewed by Harada et al., 1995); this is a far greater level of fish consumption than is typical for the general U.S. population. For the general U.S. population, the average fish consumption level is between 8 and 10 g/day (based on month-long data in NHANES III).

The first poisoning case occurred in 1956 in a six year old girl who came to a hospital complaining of symptoms characteristic of nervous system damage. Symptoms of Minamata disease in children and adults included the following:

- Impairment of the peripheral vision;
- disturbances in sensations ("pins and needles" feelings, numbness) usually in the hands and feet and sometimes around the mouth;
- incoordination of movements as in writing;
- impairment of speech;
- impairment of hearing;
- impairment of walking; and
- mental disturbances.

It frequently took several years before people were aware that they were developing the signs and symptoms of methylmercury poisoning.

Over the next 20 years the number of people known to be affected with what became known as Minamata disease increased to thousands. In time the disease was recognized to result from methylmercury poisoning, and fish were subsequently identified as the source of methylmercury. As is often the situation with epidemics, the first cases noted were severe. Deaths occurred among both adults and children. It also was recognized that the nervous system damage could occur to the fetus if the mother ate fish contaminated with high concentrations of methylmercury during pregnancy. The nervous system damage of severe methylmercury poisoning among infants was very similar to congenital cerebral palsy. In the fishing villages of this region the occurrence of congenital cerebral palsy due to methylmercury was very high compared to the incidence for Japan in general. At the height of the epidemic, mercury concentrations in fish were between 10 and 30 ppm wet weight. After the source of mercury contamination was identified, efforts were made to reduce the release of mercury into the bay. After 1969, average mercury concentrations in fish had fallen below 0.5 ppm.

In 1965, an additional methylmercury poisoning outbreak occurred in the area of Niigata, Japan. As in Minamata, multiple chemical plant sources of the chemical were considered. Scientific detective work identified the source again to be a chemical factory releasing methylmercury into the Agano River. The signs and symptoms of disease in Niigata were those of methylmercury poisoning and strongly similar to the disease in Minamata.

The abnormalities (or pathology) in the human brain that result from methylmercury poisoning are well described. There is an extremely high level of scientific certainty that methylmercury causes these changes. Similar pathology has been identified in other countries where methylmercury poisonings have occurred. Methylmercury contamination of other food products (including grains and pork products) has resulted in severe methylmercury poisoning with pathological changes in the nervous system and clinical disease virtually identical to Minamata disease.

Methylmercury poisoning occurred in Iraq following consumption of seed grain that had been treated with a fungicide containing methylmercury. The first outbreak occurred prior to 1960 and resulted in severe human poisonings. The second outbreak of methylmercury poisoning from grain consumption
occurred in the early 1970s. Imported mercury-treated seed grains arrived after the planting season and were subsequently used as grain to make into flour that was baked into bread. Unlike the long-term exposures in Japan, the epidemic of methylmercury poisoning in Iraq was short in duration, but the magnitude of the exposure was high. Because many of the people exposed to methylmercury in this way lived in small villages in very rural areas (and some were nomads), the number of people exposed to

these mercury-contaminated seed grains is not known. The number of people admitted to the hospital with symptoms of poisoning has been estimated to be approximately 6,500, with 459 fatalities reported.

As in the Japanese poisoning epidemics, the signs and symptoms of disease were predominantly those of the nervous system: difficulty with peripheral vision or blindness, sensory disturbances, incoordination, impairment of walking, slurred speech and in some cases, death. Children were affected, as well as adults. Of great concern was the observation that infants, born of mothers who had consumed the methylmercury-contaminated grain (particularly during the second trimester of pregnancy) could show nervous system damage even though the mother was only slightly affected herself.

Some Limitations of the Assessment

In both the Iraqi and Japanese epidemics, the levels of methylmercury consumed were much higher than the levels currently reported in the U.S. food supply. For example, in the Japanese epidemic, mercury concentrations in fish were between 10 and 30 ppm. Average concentrations in freshwater fish in the U.S. are roughly 0.3 ppm. The most frequently consumed marine species have mercury concentrations less than 0.2 ppm. While there are no data to indicate that methylmercury absorption is affected by food type, it must be noted that one of the severe poisoning episodes was through a means not expected to be prevalent in the U.S.; that is, the consumption of contaminated grain.

Health endpoints other than neurotoxicity were evaluated by U.S. EPA using established risk assessment Guidelines. Data for other endpoints than developmental neurotoxicity were limited. Methylmercury has been shown to cause tumors in mice at high doses that produce severe non-cancer toxicity. Low-dose exposures to methylmercury are not likely to cause cancer in humans. Data on effects related to mutation formation (changes in DNA) indicate that methylmercury could increase frequencies of mutation in human eggs and sperm. These data were not sufficient, however, to permit estimation of the amount of methylmercury that would cause a measurable mutagenic effect in a human population.

How Much Methylmercury is Harmful to Humans?

Information on the amount of methylmercury exposure producing particular combinations of signs and symptoms in people has been analyzed to yield what are called quantitative dose-response assessments. Both the Japanese and Iraqi epidemics are important to understanding how methyl-mercury from food produces neurological disease in humans. In the epidemics in Minamata and Niigata, the exposures were long-term, and the tissues of fish and shellfish were the sources of methylmercury exposure. This establishes with highest scientific confidence that methylmercury in fish can produce human disease. A limitation to these data is that many patients were severely affected. The extent of methylmercury poisoning was so severe that finding subtle indications of disease is difficult. Subtle indicators of poisoning are important for estimating the level of exposure that will not cause adverse effects. The U.S. EPA calculates one such estimate, called a reference dose or RfD (see the box "What Is a Reference Dose?").

U.S. EPA has on two occasions published RfDs for methylmercury which have represented the Agency consensus for that time. These are discussed at length in Volume IV, and the uncertainties and limitations are described in Volume VI. At the time of the generation of the Mercury Study Report to Congress, it became apparent that considerable new data on the health effect of methylmercury in humans were emerging. Among these are large studies of fish or fish and marine mammal consuming populations in the Seychelles and Faroes Islands. Smaller scale studies are in progress which describe effects in populations around the U.S. Great Lakes. In addition, there are new evaluations, including novel statistical approaches and application of physiologically-based pharmacokinetic models to

published work. The U.S. EPA has been advised by scientific reviewers to employ this RfD for this analysis. Because of various limitations and uncertainties in the Iraqi data set, the U.S. EPA and other federal agencies intend to participate in an interagency review of all the human data on methylmercury, including the more comprehensive studies from the Seychelles and Faroe Islands. The purpose of this review is to reduce the level of uncertainty attending current estimates of the level of exposure to mercury associated with subtle neurological endpoints. After this process, the U.S. EPA will re-assess its RfD for methylmercury to determine if change is warranted.

The current U.S. EPA RfD for methylmercury was based on data on neurologic changes in 81 Iraqi children who had been exposed *in utero*: their mothers had eaten methylmercury-contaminated bread during pregnancy. The data were collected by interviewing the mothers of the children and by clinical examination by pediatric neurologists approximately 30 months after the poisoning episode. The incidence of several endpoints (including late walking, late talking, seizures or delayed mental development, and scores on clinical tests of nervous system function) were mathematically modeled by U.S. EPA to determine a mercury level in hair (measured in all the mothers in the study) which was associated with no adverse effects. These effects were delays in motor and language development defined by the following:

- Inability to walk two steps without support by two years of age;
- inability to respond to simple verbal communication by age 2 years among children with good hearing;
- scores on physical examination by a neurologist that assessed cranial nerve signs, speech, involuntary movements, limb tone, strength, deep tendon reflexes, plantar responses, coordination, dexterity, primitive reflexes, sensation, posture, and ability to sit, stand, walk, and run; and
- assessment of mental development or the presence of seizures based on interviews with the child's mother.

In calculating the mercury level in hair which was associated with no adverse effects, the U.S. EPA chose a benchmark dose approach based on modeling of all effects in children. The benchmark dose is the intake of methylmercury associated with the lower bound (that is the lower limit) on a 95 percent confidence interval of a dose producing a 10 percent prevalence of adverse effects. The 95 percent confidence interval indicates there is a 5 percent likelihood that the effect reported was due to chance alone. The effects used as end-point of adverse neurological effects included delayed walking, delayed talking, and abnormal neurological scores (see p. 3-38 for details). This lower bound was 11 ppm hair concentration for methylmercury. A dose–conversion equation was used to estimate a daily intake of 1.1 μg methylmercury/kg body weight/day that when ingested by a 60 kg individual will maintain a blood concentration of approximately 44 μg/L of blood or a hair concentration of 11 μg mercury/gram hair (11 ppm). Mothers with hair concentrations below that associated with the RfD (1 ug Hg/g hair) are unlikely to experience adverse effects.

Data on the behavior of mercury in the human body were used to estimate the amount of mercury ingested per day at this no adverse effect level. Due to variability in the way individuals process methylmercury in the body and the lack of data on observed adult male and female reproductive effects, an uncertainty factor of 10 was used to derive the RfD from the benchmark dose. The RfD for methylmercury was determined to be 1×10^{-4} mg/kg–day; that is a person could consume 0.1 μg methylmercury for every kg of his/her body weight every day for a lifetime without anticipation of risk of

What Is A Reference Dose?

A reference dose or RfD is defined in the following way by U.S. EPA: an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are reviewed by Agency scientists for accuracy, appropriate use of risk assessment methodology, appropriate use of data and other scientific issues. When consensus has been reached by the workgroup, information on the RfD is made available to the public through a U.S. EPA database; namely, the Integrated Risk Information System (IRIS).

The RfD is based on the best available data that indicate a "critical effect"; this is generally the first indicator or most subtle indicator of an adverse effect in the species under study. In calculating RfDs U.S. EPA generally uses a no observed adverse effect level (NOAEL). This is found from either inspection or modeling of dose-response data on the critical effect. It is a means of estimating the threshold for effect in the reported study. The NOAEL is most useful when it is from a study in which a determination of the lowest observed adverse effect level (LOAEL) can also be done. The LOAEL is the lowest tested dose at which the critical effect was seen in the species under study.

In calculating the RfD the U.S. EPA divides the NOAEL or LOAEL by a series of uncertainty and modifying factors in order to extrapolate to the general human population. The uncertainty factors (which may be as much as 10 each) are for the following areas: extrapolation of data to sensitive human subpopulations; extrapolation from animal data to conclusions for humans; lack of chronic data; lack of certain other critical data; and use of a LOAEL in the absence of a NOAEL.

The RfD is used for risk assessment judgments dealing with evaluations of general systemic toxicity. It is intended to account for sensitive (but not hypersensitive) members of the human population; the rationale is that if exposure to the RfD is likely to be without appreciable risk for sensitive members of the population, then it is without appreciable risk for all members of the population. The RfD is generally applicable to men and women and to adults, to children and to the aged, unless data support the calculation of separate RfDs for these groups.

The RfD is a quantitative estimate of levels expected to be without effect even if exposure persists over a lifetime. It is not intended to be compared with isolated or one time exposures. Exceedance of the RfD does not mean that risk will be present. Acceptability of uncertain risks is a risk management decision. Risk management decisions may consider the RfD but will take into account exposures, other risk factors and non-risk factors as well. At the RfD or below, exposures are expected to be safe. The risk following exposures above the RfD is uncertain, but risk increases with increasing exposures.

adverse effect. The RfD is a daily ingestion level anticipated to be without adverse effect to persons, including sensitive subpopulations, over a lifetime. The RfD may be considered the midpoint in an estimated range of about an order of magnitude. This range reflects variability and uncertainty in the estimate. At the RfD or below, exposures are expected to be safe. The risk following exposures above the RfD is uncertain but risk increases with increasing exposure.

The RfD is a risk assessment tool, not a risk management decision. Judgments as to a "safe" dose and exposure represent decisions that involve risk management components.

Limitations and Uncertainties in the Assessment

The range of uncertainty in the RfD and the factors contributing to this range were evaluated in qualitative and quantitative uncertainty analyses. The uncertainty analyses indicated that paresthesia (numbness or tingling) in the hands and feet, and occasionally around the mouth, in adults is not the most reliable endpoint for dose–response assessment because it is subject to the patient's recognition of the effect. Paresthesia in adults is no longer the basis for U.S. EPA's methylmercury RfD as it was in the mid-1980s. There are, however, uncertainties remaining on the current RfD based on developmental effects from methylmercury in children exposed *in utero*. There are difficulties with reliability in recording and classifying events like late walking in children, especially as the data were collected approximately 30 months after the child's birth. It should be noted, however, that the endpoints used represented substantial developmental delays; for example, a child's inability to walk two steps without support at two years of age, inability to talk based on use of two or three meaningful words by 24 months, or presence of generalized convulsive seizures. There is uncertainty in the physiologic factors which were used in estimating the ingested mercury dose. There is also a degree of uncertainty introduced by the size of the study population (81 mother-child pairs).

The RfD is supported by investigations of laboratory animals under controlled exposures to methylmercury. Data from experimental animals (including primates with long-term exposures to methylmercury) show methylmercury-induced nervous system damage, particularly on the visual system, although the animals appeared clinically normal. The endpoints described in the animal literature are important and these have been induced by dosing protocols that are relevant to human exposures. In experiments using nonhuman primates, sensory (visual, somatosensory, auditory), cognitive (learning under concurrent schedules, recognition of faces), social play, and schedule-controlled operant behavior are all identified as having been adverse affected by methylmercury. The sensory, cognitive, and motor deficits appear reliably over a consistent range of doses in nonhuman primates exposed to methylmercury during development. Subtle, but important deficits, appear in several functional domains. These are identifiable signs of methylmercury effects when appropriate testing conditions are applied.

The RfD is supported by additional studies in children exposed *in utero*. These include investigations among Cree Indians in Canada and New Zealanders consuming large amounts of fish. In these studies the hair concentration of mercury is used to monitor mercury exposure over time. Conclusions by the investigators in their official reports cite developmental delays among the children born of mothers whose hair mercury concentrations during pregnancy were 6 to 18 μg/g, consistent with the benchmark dose of 11 μg/g.

Currently a number of research studies are underway that further address the question of what exposures to methylmercury in fish are associated with neurological disease. These studies include more subjects than did the Iraqi study, are prospective in design, and utilize endpoints that are anticipated to be more sensitive than the clinical signs and symptoms of methylmercury poisoning observed in Iraq. These studies of developmental effects of mercury exposure secondary to fish and shellfish consumption, rather than poisoning, are conducted in the Seychelles Islands in the Indian Ocean (sponsored, in part by the Department of Health and Human Services), the Faroe Islands in the North Atlantic Ocean (sponsored, in part, by the United States Environmental Protection Agency and by the United States Department of Health and Human Services), and in the United States; this last study is sponsored by the Agency for Toxic Substances and Disease Registry (ATSDR).

Data from both the Seychelle Islands cohort and the Faroe Islands cohort have been published during 1996 and 1997. These data should be useful in decreasing the uncertainty surrounding both the benchmark dose and the RfD, however, statistical analyses for purposes of risk assessment have been

recommended by the U.S. EPA's Science Advisory Board. In addition to these two major prospective investigations, additional studies evaluating the effect of methylmercury exposures from fish and shellfish in human subjects from other geographic areas are anticipated to be published in the peer-reviewed literature within the period 1997/1998. The U.S. FDA has determined that revisions of its action level for mercury concentrations of fish in interstate commerce should wait until the new studies have reduced the level of uncertainty. The availability of results from the above studies will likewise enable U.S. EPA to re-examine and adjust its RfD as needed.

Levels of Methylmercury Exposure Addressed by the U.S. Food and Drug Administration, World Health Organization and State Recommendations

The U.S. EPA RfD is a daily intake level and is a risk assessment tool; the use of the RfD is not limited to fish. The discussion that follows covers risk assessment and risk management activities concerning fish. These consider fish consumption patterns and risk management policy factors.

There are numerous local and state warnings in the U.S. to limit intake of fish because of chemical contamination. Warnings are issued because of a number of contaminants. Methylmercury is most often included as one of the contaminants that form the basis for the warning. Often these warnings are issued based on local conditions.

Recommended limits on methylmercury exposure have been expressed in these units: μg/kg body weight/day; concentrations of mercury in tissues such as blood, hair, feathers, liver, kidney, brain, etc.; grams of fish per day; number of fish meals per time interval (e.g., per week). Reference values for mercury concentrations (expressed as total mercury) in biological materials commonly used to indicate human exposures to mercury were published by the WHO/IPCS (1990). The mean concentration of mercury in whole blood is approximately 8 μg/L, in hair about 2 μg/g, and in urine approximately 4 μg/L. Wide variation occurs about these values (WHO/IPCS, 1990).

A number of different estimates exist for hair mercury levels that are associated with low risks of neurological endpoints such as paresthesia. These estimates are sensitive to variables such as the half-life of mercury in the body (time to eliminate half the dose of mercury). Half-life is usually estimated as an average of 70 days, with extremes of about 35 to just over 200 days reported for different individuals. The half-life of mercury in pregnant women has not been directly measured. The half-life of mercury in women during lactation is shorter, possibly due to excretion of mercury into milk produced during lactation.

Cross-comparison of World Health Organization (WHO) recommendations regarding risk associated with hair mercury concentrations is facilitated by data reported by the WHO on mercury concentrations in 559 samples of human head hair from 32 locations in 13 countries. The WHO report found that mercury concentrations in hair increased with increasing frequency of fish consumption (see Table 3-4).

Table 3-4
WHO Data on Mercury in Hair

Fish Consumption Frequency	Average Mercury Concentration in Hair (μg mercury per g of hair)
No unusual mercury exposure	2
Less than one fish meal per month	1.4 (range 0.1 to 6.2)
Fish meals twice a month	1.9 (range 0.2 to 9.2)
One fish meal a week	2.5 (range 0.2 to 16.2)
One fish meal each day	11.6 (range 3.6 to 24.0)

The World Health Organization's International Programme for Chemical Safety (WHO/IPCS) provided estimates of risk of neurological effects from methylmercury exposures for adults and fetuses. Adult effects occur at higher exposures to methylmercury than do fetal effects. WHO/IPCS concluded that the general population of adults (males and non-pregnant females) does not face a significant health risk from methylmercury when hair mercury concentrations are under 50 µg mercury/gram hair. In recent evaluations of the Niigata epidemic of Minamata disease, study authors reported lower thresholds with mean values in the range of 25 to approximately 50 µg mercury/gram hair.

Clinical observations in Iraq suggest that women during pregnancy are more sensitive to the effects of methylmercury because of risk of neurological damage to the fetus. The WHO/IPCS (1990) analyzed the Iraqi data and identified a 30 percent risk to the infant of abnormal neurological signs when maternal hair mercury concentrations were over 70 µg/g. Using an additional statistical analysis, WHO/IPCS estimated a 5 percent risk of neurological disorder in the infant when the maternal hair concentration was 10 to 20 µg mercury/gram of hair. The recommendations of WHO/IPCS are based on clinically observable neurological changes as the indicator of effect. U. S. EPA's benchmark dose is associated with a hair mercury concentration of 11 µg/g hair and clinically observable endpoints in the child following in utero methylmercury exposures to the mother. The RfD is one-tenth the benchmark dose because U.S. EPA applied an uncertainty factor of 10. The U.S. EPA RfD is within an order of magnitude of the dose described by WHO.

In addition to their recommendations on hair mercury concentrations WHO/IPCS recommended that as a preventive measure, in a subpopulation that consumes large amounts of fish (for example, one serving or 100 grams per day), hair levels for women of child–bearing age should be monitored for methylmercury.

The WHO/IPCS estimated (1990) that a daily methylmercury intake of 0.48 µg mercury/kg body weight will not cause any adverse effects to adults and that a methylmercury intake of 3 to 7 µg/kg body weight/day would result in a <5 percent increase in the incidence of paresthesia in adults. Risk to this extent would be associated with hair mercury concentration of approximately 50 to 125 µg mercury per gram hair. By comparison, the U.S. EPA's reference dose, or the amount of methylmercury any person (including children and pregnant women) can ingest every day without harm is 0.1 µg/kg body weight per day. This was based on a benchmark dose equal to 11 ppm (µg/g) hair. Children are expected to have a higher exposure to methylmercury (on a per kg body weight basis) than do adults.

In 1969, in response to the poisonings in Minamata Bay and Niigata, Japan, the U.S. FDA proposed an administrative guideline of 0.5 ppm for mercury in fish and shellfish moving in interstate

commerce. This limit was converted to an action level in 1974 (Federal Register 39, 42738, December 6, 1974) and increased to 1.0 ppm in 1979 (Federal Register 44, 3990, January 19, 1979) in recognition that exposure to mercury was less than originally considered. In 1984, the 1.0 ppm action level was converted from a mercury standard to one based on methylmercury (Federal Register 49, November 19, 1984).

FDA's action level is based on consideration of the tolerable daily intake (TDI) for methylmercury, as well as information on seafood consumption and associated exposure to methylmercury. The TDI is the amount of methylmercury that can be consumed daily over a long period of time with a reasonable certainty of no harm to adults. The neurological endpoint evaluated was paresthesia (see WHO description above for more information). U.S. FDA (and WHO) established a TDI based on a weekly tolerance of 0.3 mg of total mercury per person, of which no more than 0.2 mg should be present as methylmercury. These amounts are equivalent to 5 and 3.3 μg, respectively, per kilogram of body weight. Using the values for methylmercury, this tolerable level would correspond to approximately 230 μg/week for a 70 kg person or 33 μg/person/day. The TDI was calculated from data developed in part by Swedish studies of Japanese individuals poisoned in the episode of Niigata which resulted from the consumption of contaminated fish and shellfish and the consideration of other studies of fish-eating populations.

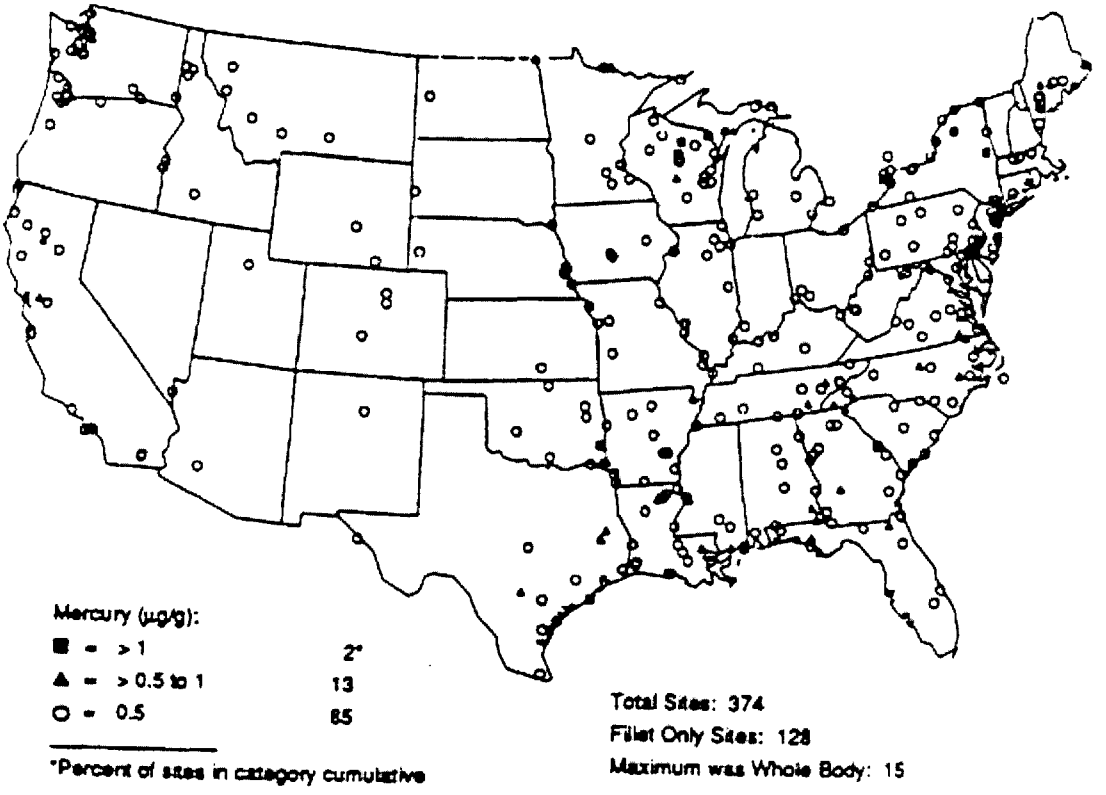
Based on observations from the poisoning event later in Iraq, U.S. FDA has acknowledged that the fetus may be more sensitive than adults to the effects of mercury (Federal Register 44: 3990, January 19, 1979; Cordle and Tollefson, 1984, U.S. FDA Consumer, September, 1994). In recognition of these concerns, U.S. FDA has provided advice to pregnant women and women of child-bearing age to limit their consumption of fish known to have high levels of mercury (U.S. FDA Consumer, 1994). U.S. FDA believes, however, that given existing patterns of fish consumption, few women (less than 1%) eating such high mercury fish will experience slight reductions in the margin of safety. However, due to the uncertainties associated with the Iraqi study, U.S. FDA has chosen not to use the Iraqi study as a basis for revising its action level. Instead, the U.S. FDA has chosen to wait for findings of prospective studies of fish-eating populations in the Seychelles Islands and in the Faroes Islands.

Characterization of Risk to Human Populations

The characterization of risk to U.S. human populations focuses on exposure to methylmercury. Although methylmercury is found in other media and biota, it accumulates to the highest concentrations in the muscle tissue of fish, particularly fish at the top of the aquatic food chain. As a result, fish ingestion is the dominant exposure pathway. The dominance of this pathway reflects both bioaccumulation of methylmercury in the fish and the efficiency with which methylmercury passes through intestinal walls. The critical elements in estimation of methylmercury exposure from fish are these: the species of fish consumed; the concentration of methylmercury in the fish; the quantity consumed and the frequency of consumption.

There are three ways to assess the risk to populations from methylmercury exposure. The first way used in this analysis was based on predicted increases in methylmercury concentrations in fish due to anthropogenic emissions coupled with predicted exposure to human (and wildlife) populations. This type of analysis has the advantage of predicting the direct impact of anthropogenic emissions on fish concentrations. The second way risk was assessed was by using dietary surveys to identify the amount and type of fish consumed by populations in the U.S. The advantage of this methodology is that a total exposure from fish can be evaluated, even though the contamination may have come from sources other than anthropogenic emissions. The third way to determine whether members of the population are at risk was to consider hair mercury levels as methylmercury exposures for the general populations are reflected by these levels. This type of assessment would be one appropriate measurement of actual mercury

Figure 3-4
Distribution of Mercury Concentrations in U.S. EPA-Sampled Fish Tissue Throughout the U.S.



The FDA advises persons other than pregnant women and women of child-bearing age to limit their consumption of fish species with methylmercury levels around 1 ppm to about 7 ounces per week (about 1 serving). For fish with levels averaging 0.5 ppm, regular consumption should be limited to about 14 ounces per week (about two servings). Consumption advice is unnecessary for the top 10 seafood species listed in Table 3-6 as mercury levels are 0.2 ppm or less and few people eat more than the suggested weekly limit of fish (2.2 pounds) for this level of contamination. FDA made this latter statement for all segments of the population, including women who might become pregnant.

Human Exposure to Methylmercury Based on Dietary Surveys

Estimates of the number of individuals who exceed various recommendations on exposures to mercury are characterized by both uncertainty and variability. In its review of U.S. EPA's earlier draft of this Report, the Science Advisory Board noted that the high end of the distribution of methylmercury exposures is very uncertain with respect to exposures, total number of people (and percent of the population) who

Table 3-6
Mercury Concentrations in the Top Ten Types of Fish/Shellfish Consumed by U.S. Residents

Fish[a]	Mercury Concentration (ppm, wet weight)[b]	Comments
Tuna	0.206	The mercury content for tuna is the average of the mean concentrations measured in 3 types of tuna: albacore tuna (0.264 ppm), skipjack tuna (0.136 ppm) and yellowfin tuna (0.218 ppm). The U.S. FDA measured the methylmercury concentration in 220 samples of canned tuna in 1991; the average amount of methylmercury measured in these samples was 0.17 ppm and the measured range was <0.1 - 0.75 ppm (Yess, 1993).
Shrimp	0.047	The mercury content for shrimp is the average of the mean concentrations measured in seven types of shrimp: royal red shrimp (0.074 ppm), white shrimp (0.054 ppm), brown shrimp (0.048 ppm), ocean shrimp (0.053 ppm), pink shrimp (0.031 ppm), pink northern shrimp (0.024 ppm) and Alaska (sidestripe) shrimp (0.042 ppm).
Pollack	0.15	The Pesticide and Chemical Contaminant Data Base for U.S. FDA (1991/1992) reports the methylmercury concentration in pollack in commerce as 0.04 ppm.
Salmon	0.035	The mercury content for salmon is the average of the mean concentrations measured in five types of Salmon: pink (0.019 μg/g), chum (0.030 ppm), coho (0.038 ppm), sockeye (0.027 ppm), and chinook (0.063 ppm).
Cod	0.121	The mercury content for cod is the average of the mean concentrations in Atlantic Cod (0.114 ppm) and the Pacific Cod (0.127 ppm).
Catfish	0.088 0.16	The sources of mercury content in catfish are Bahnick et al., 1994 and Lowe et al., 1985. Both data sets were collected from U.S. freshwater sources. The Bahnick data (mean = 0.088) include channel, largemouth, rock, striped and white catfish, and the Lowe data (mean = 0.16) include channel and flathead catfish. It should be noted that neither survey included farm-raised catfish, which is the type of catfish predominantly consumed in the U.S. The mercury content of farm-raised catfish may be significantly different than freshwater sources. The Pesticide and Chemical Contaminant Data Base for U.S. FDA (1991/1992) reports the methylmercury concentration in farm-raised catfish as 0.02 ppm.
Clam	0.023	The mercury content for clam is the average of the mean concentrations measured in four types of clam: hard (or quahog) clam (0.034 ppm), Pacific littleneck clam (0 ppm), soft clam (0.027 ppm), and geoduck clam (0.032 ppm).

Table 3-6 (continued)
Mercury Concentrations in the Top Ten Types of Fish/Shellfish Consumed by U.S. Residents

Fish[a]	Mercury Concentration (ppm, wet weight)[b]	Comments
Flatfish (Flounder)	0.092	The mercury content for flounder is the average of the mean concentrations measured in nine types of flounder: Gulf (0.147 ppm), summer (0.127 ppm), southern (0.078 ppm), four-spot (0.090 ppm), windowpane (0.151 ppm), arrowtooth (0.020 ppm), witch (0.083 ppm), yellowtail (0.067 ppm), and winter (0.066 ppm).
Crab	0.117	The mercury content for crab is the average of the mean concentrations measured in five types of crab: blue crab (0.140 ppm), dungeness crab (0.183 ppm), king crab (0.070 ppm), tanner crab (*C. opilio*) (0.088 ppm), and tanner crab (*C. bairdl*) (0.102 ppm).
Scallop	0.042	The mercury content for scallop is the average of the mean concentrations measured in four types of scallop: sea (smooth) scallop (0.101 ppm), Atlantic Bay scallop (0.038 ppm), calico scallop (0.026 ppm), and pink scallop (0.004 ppm).

[a] List of fish types from U.S. FDA (1995).
[b] Mercury concentrations sources are described in the comments, refer to Volume III for complete citations.

may be experiencing exposures high enough to cause adverse health effects, and the actual subgroups who are highly exposed. Consequently, the total population at risk is not, and cannot be fully characterized at this time.

Because of the uncertainties intrinsic to describing fully the high-end of the distribution, where multiple estimates of the size of the highly exposed population are available, a range of values has been presented. Predicted high exposures to methylmercury are caused by one of two factors or their combination: 1) consumption of types of fish which exhibit elevated methylmercury concentrations in their tissues; and or 2) high consumption rates of methylmercury contaminated fish.

The discussion of the modeling analysis above focused on potential risk to human populations due to consumption of fish having relatively high concentrations of mercury. A limitation of the modeling analysis is that the size of the population potentially at increased risk cannot be estimated because hypothetical water body locations and exposure scenarios are employed. The analysis of mercury exposure using dietary surveys described below is aimed at identifying populations that eat much greater amounts of fish than the average consumer. Their potential for increased risk is not necessarily due to elevated concentrations in fish, it is more a function of the amount of fish consumed on a regular, usually daily, basis. The analysis of the at-risk population eating above average amounts of fish focuses on that part of the population which consumes on average 100 grams or more of fish or shellfish per day (approximately 3.5 ounces). The basis for this focus on persons eating 100 grams or more is a recommendation made by the World Health Organization's International Programme for Chemical Safety (WHO) that populations consuming large amounts of fish and shellfish require special consideration. The 100 gram per day recommendation by the WHO can be used as a screening analysis to identify populations potentially at increased risk; particularly risk among pregnant women. The

significance of the risk is, as mentioned above, is also a function of the methylmercury concentrations of the fish consumed. Figure 3-5 illustrates the distribution of fish consumption rates of various populations. As shown in Figure 3-5, the general U.S. population consumes, on average, far less fish than subsistence fishers and some Native American tribes which have been studied. Figure 3-5 also illustrates that some members of the U.S. population do consume fish in large amounts on a daily basis.

The second way dietary surveys were used in this analysis was to calculate methylmercury exposure over a month-long period. This can be achieved by combining the frequency distribution of month-long patterns of fish/shellfish consumption with dietary data indicating the species of fish consumed, average values for mercury concentrations in the species of fish consumed, the portion size consumed, and the individuals' body weights.

The U.S. EPA used two types of dietary surveys to identify these populations. Dietary surveys can be classified into longitudinal or cross-sectional surveys. Cross-sectional data are used to give a "snap shot" in time and are typically used to provide information on the distribution of intakes for groups within the population of interest. Cross-sectional data typically are for 24-hour or 3-day sampling periods and may rely on recall of foods consumed following questioning by a trained interviewer, or may rely on written records of foods consumed. The cross-sectional surveys used in this Report were the Continuing Surveys of Food Consumption by Individuals for the periods 1989 to 1991, 1994 and 1995 and the third National Heath and Nutrition Examination Survey (NHANES III) conducted between 1988 and 1994.

General U.S. Population. NHANES III obtained data on the self-reported month-long frequency of consumption of fish and shellfish by respondents in this survey. Of the adults surveyed 86 percent reported they ate fish or shellfish at least once during the previous month. Major subgroups in the general population indicated they consumed fish and shellfish more frequently than did the overall population. Among persons who designated themselves as "White/NonHispanic," 1.9 percent consumed fish/shellfish 6.4 times or more a week. Within the subpopulation of persons who categorized themselves as "Black/NonHispanic," 3.3 percent consumed fish/shellfish 6 times or more per week. Among persons who categorized themselves as "Other" (typically individuals of Asian/Pacific Islander ethnicity, Native Americans, Alaskan Natives, and persons of Caribbean ethnicity), 8.9 percent indicated they consumed fish/shellfish 6 times or more a week.

Subpopulations of Concern. Three groups are potentially at increased risk from methylmercury: pregnant women, women of child-bearing age (i.e., between the ages of 15 and 44) and children ages 14 and younger. Pregnant women are of concern because of the adverse effects of methylmercury on the fetal nervous system. Women of child-bearing age rather than only pregnant women are of concern for two reasons. The first is that methylmercury persists in tissues. Measured half-lives for methylmercury in adults range from about 1 month to 9 months, although half-lives of just over 2 months are usually observed. Thus, dietary intakes just prior to pregnancy are of concern rather than only methylmercury intakes during pregnancy. The second reason is that women usually do not know they are pregnant until the pregnancy is past many of the critical stages of fetal development.

Children may be at a higher risk of methylmercury exposure than are adults because they appear to have higher exposures on a per kilogram body weight basis, and they may be inherently more sensitive than adults given the developmental state of the nervous system. In the methylmercury poisoning epidemics in Japan and Iraq, children were affected, as well as adults. These effects were not seen only in children exposed to methylmercury *in utero*, but included children exposed through ingesting methylmercury from food. Whether or not children differ from adults in sensitivity to methylmercury neurotoxicity is not known.

Mercury Fate and Transport Modeling

During the development of the mercury fate and transport assessment, many areas of uncertainty and significant data gaps were identified. Many of these have been identified in the document, and several are presented in the following list.

1. Improved analytical techniques for measuring speciated mercury air emissions are needed as well as total mercury emissions from point sources. Laboratory evidence suggests that divalent mercury gas emissions will wet and dry deposit much more readily than elemental mercury gas. Particle-bound mercury is also likely to deposit relatively quickly. Current stack sampling methods do not provide sound information about the fraction of mercury emissions that are in oxidized form. While filters are used to determine particulate mercury fractions, high temperature stack samples may not be indicative of the fraction of mercury that is bound to particles after dilution and cooling in the first few seconds after emission to the atmosphere. Methods for determination of the chemical and physical forms of mercury air emissions after dilution and cooling need to be developed and used to characterize significant point sources.

2. Evaluated local and regional atmospheric fate and transport models are needed. These models should treat all important chemical and physical transformations which take place in the atmosphere. The development of these models will require comprehensive field investigations to determine the important atmospheric transformation pathways (e.g., aqueous cloud chemistry, gas-phase chemistry, particle attachment, photolytic reduction) for various climatic regions.

3. The evaluation of these models will require long-term national (possibly international) monitoring networks to quantify the actual air concentrations and surface deposition rates for the various chemical and physical forms of mercury.

4. Better understanding of mercury transport from watershed to water body including the soil chemistry of mercury, the temporal aspects of the soil equilibrium and the impact of low levels of volatile mercury species in surface soils and water bodies on total mercury concentrations and equilibrium.

5. Better understanding of foliar uptake of mercury and plant/mercury chemistry. (The most important questions: do plants convert elemental or divalent mercury into forms of mercury that are more readily bioaccumulated? Do plants then emit these different forms to the air?) A better understanding of the condensation point for mercury is needed.

6. Better understanding of mercury movement from plant into soil (detritus). May need to refine the models used to account for movement of mercury in leaf litter to soil.

7. The impact of anthropogenic mercury on the "natural," existing mercury levels and species formed in soil, water, and sediments needs better understanding. How does the addition of anthropogenic mercury affect "natural" soil and water mercury cycles? Natural emission sources need to be studied better and their impacts better evaluated.

8. Improved understanding of mercury flux in water bodies and impact of plant and animal biomass are needed. Unlike many other pollutants, most of the methylmercury in a water body appears to be in the biological compartment. The sedimentation rate as well

as benthic sediment:water partition coefficient require field evaluation. Important to consider rivers and other larger water bodies in these flux analyses.

Exposure from Anthropogenic Mercury Emissions in the United States

1. To improve the quantitative exposure assessment modeling component of the risk assessment for mercury and mercury compounds, U.S. EPA would need more and better mercury emissions data and measured data near sources of concern, as well as a better quantitative understanding mor mercury chemistry I the emission plume, the atmosphere, soils, water bodies, and biota.

2. To improve the exposure estimated based on surveys of fish consumption, more study in needed among potentially high-end fish consumers, which examines specific biomarkers indicating mercury exposure (e.g., blood mercury concentrations and hair mercury concentrations).

3. A pharmacokinetic-based understanding of mercury partitioning in children is needed. Additional studies of fish intake and methylmercury exposure among children are needed.

Health Effects of Mercury and Mercury Compounds

1. In addition to the ongoing studies identified in the health effects review, further research is necessary for refinement of the U.S. EPA's risk assessments for mercury and mercury compounds. In order to reduce uncertainties in the current estimates of the oral reference doses (RfDs) and inhalation reference concentrations (RfCs), longer-term studies with low-dose exposures are necessary. In particular, epidemiological studies should emphasize comprehensive exposure data with respect to both dose and duration of exposure. Some studies should be targeted to populations identified in this Report as likely to experience methylmercury exposure in fish (e.g., subsistence fishers).

2. The current RfD and RfC values have been determined for the most sensitive toxicity endpoint for each compound; that is, the neurological effects observed following exposure to elemental or methylmercury, and the renal autoimmune glomerulonephritis following exposure to inorganic mercury. For each of these compounds, experiments conducted at increasingly lower doses with more sensitive measures of effect will improve understanding of the respective dose-response relationships at lower exposure levels and the anticipated thresholds for the respective effects in humans. Similar information from developmental toxicity studies would allow determination of RfDs for developmental toxicity (RfD_{dt}) for elemental and inorganic mercury.

3. Research needs include studies which will delineate the most appropriate indicators of neurotoxic effects for exposed adults, children and individuals exposed to methylmercury *in utero*. Well conducted studies are also needed to clarify critical levels at which other toxic effects could occur in humans.

4. Well-conducted studies are also needed to clarify exposure levels at which toxic effects other than those defined as "critical" could occur in humans. For all three forms of mercury, data are inadequate, conflicting, or absent for the following: adverse reproductive effects (effects on function or outcome, including multigeneration

exposure); impairment of immune function; and genotoxic effects on human somatic or germinal cells (elemental and inorganic mercury).

5. Investigations that relate the toxic effects to biomonitoring data will be invaluable in quantifying the risks posed by these mercury compounds. In addition, work should focus on subpopulations that have elevated risk because they are exposed to higher levels of mercury at home or in the workplace, because they are also simultaneously exposed to other hazardous chemicals, or because they have an increased sensitivity to mercury toxicity.

6. There are data gaps in the carcinogenicity assessments for each of the mercury compounds. The U.S. EPA's weight-of-evidence classification of elemental mercury (Group D) is based on studies in workers who were also potentially exposed to other hazardous compounds including radioactive isotopes, asbestos, or arsenic. There were no appropriate animal studies available for this compound. Studies providing information on the mode of action of inorganic mercury and methylmercury in producing tumors will be of particular use in defining the nature of the dose response relationship.

7. The assessment of both noncarcinogenic effects and carcinogenic effects will be improved by an increased understanding of the toxicokinetics of these mercury compounds. In particular, quantitative studies that compare the three forms of mercury across species and/or across routes of exposure are vital for the extrapolation of animal data when assessing human risk. For elemental mercury there is a need for quantitative assessment of the relationship between inhaled concentration and delivery to the brain or fetus; in particular the rate of elemental to mercuric conversion mediated by catalase and the effect of blood flow. Such assessment is needed for evaluation of the impact of mercury exposure from dental amalgam.

8. Work has been done on development of physiologically-based pharmacokinetic models. While one of these has developed a fetal submodel, data on fetal pharmacokinetics are generally lacking. The toxicokinetics of mercury as a function of various developmental stages should be explored. Elemental mercury and methylmercury appear to have the same site of action in adults; research is, therefore, needed on the potential for neurotoxicity in newborns when the mother is exposed. This work should be accompanied by pharmacokinetic studies and model development.

Ecological Assessment for Anthropogenic Mercury Emissions in the United States

1. *Process-based Research.* Mechanistic information is needed to understand the variability that presently typifies the mercury literature. This research includes laboratory and field studies to identify the determinants of mercury accumulation in aquatic food chains and kinetic information that would allow researchers to describe the dynamics of these systems. Areas of uncertainty include: (1) translocation of mercury from watersheds to waterbodies; (2) factors that determine net rates of methylation and demethylation; (3) dietary absorption efficiency from natural food sources; (4) effect of dietary choice; and (5) bioavailability of methylmercury in the presence of dissolved organic material and other potential ligands. In time, it is anticipated that this information can be used to develop process-based models for mercury bioaccumulation in fish and other aquatic biota. Significant progress in this direction is represented by the Mercury Cycling Model (MCM) (Hudson et al., 1994) and by the ISC3M model described in Volume III of this Report and employed in the wildlife exposure characterization.

MERCURY AND THE RISK OF CORONARY HEART DISEASE IN MEN

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ABSTRACT

Background A high dietary intake of mercury from consumption of fish has been hypothesized to increase the risk of coronary heart disease.

Methods Using a nested case–control design, we investigated the association between mercury levels in toenails and the risk of coronary heart disease among male health professionals with no previous history of cardiovascular disease or cancer who were 40 to 75 years of age in 1986. Toenail clippings were collected in 1987 from 33,737 cohort members, and during five years of follow-up, we documented 470 cases of coronary heart disease (coronary-artery surgery, nonfatal myocardial infarction, and fatal coronary heart disease). Each patient was matched according to age and smoking status with a randomly selected control subject.

Results The mercury level was significantly correlated with fish consumption (Spearman r=0.42, P< 0.001), and the mean mercury level was higher in dentists than in nondentists (mean, 0.91 and 0.45 μg per gram, respectively; P<0.001). After age, smoking, and other risk factors for coronary heart disease had been controlled for, the mercury level was not significantly associated with the risk of coronary heart disease. When the highest and lowest quintiles of mercury level were compared, the relative risk of coronary heart disease was 0.97 in the highest level (95 percent confidence interval, 0.63 to 1.50; P value for trend=0.78). Adjustment for intake of n–3 fatty acids from fish did not appreciably change these results.

Conclusions Our findings do not support an association between total mercury exposure and the risk of coronary heart disease, but a weak relation cannot be ruled out. (N Engl J Med 2002;347:1755-60.)

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SEVERAL lines of evidence suggest that oxidation of low-density lipoprotein (LDL) in the arterial intima has an important role in atherogenesis.[1-3] Mercuric chloride increased hydrogen peroxide formation and depleted glutathione in rats.[4] In a prospective cohort study in eastern Finland, fish consumption and the levels of mercury in the hair were positively associated with the risk of coronary heart disease and with serum titers of immune complexes containing oxidized LDL. The authors hypothesized that the associations were due to catalysis of lipid peroxidation by mercury, with which fish in the region are highly contaminated.[5]

Cadmium is also postulated to increase the risk of hypertension and coronary heart disease,[6,7] but the evidence is limited and inconsistent.[8] In studies in animals, the administration of mercury modifies the distribution and retention of injected cadmium in various organs,[9,10] a result that suggests an interaction between cadmium and mercury. Selenium is thought to antagonize some of the adverse effects of mercury.[11-16]

In this analysis, we assessed the association between base-line levels of mercury in the toenails and the subsequent risk of coronary heart disease among men in the Health Professionals Follow-up Study. Because the majority of participants are dentists, who have occupational as well as dietary exposures to mercury, the range of mercury burden was unusually wide. The assessment included the evaluation of possible interactions of mercury with cadmium and selenium.

METHODS

Study Population

The Health Professionals Follow-up Study is a prospective cohort study of the relation between diet and coronary heart disease and cancer among 51,529 men who were 40 to 75 years old in 1986. The population includes 29,683 dentists, 10,098 veterinarians, 485 pharmacists, 3745 optometrists, 2218 osteopathic physicians, and 1600 podiatrists. The study began in 1986, when all cohort members completed a mailed questionnaire about dietary intake, risk factors for heart disease, and medical history. Every two years, follow-up questionnaires were sent to obtain updated information on newly diagnosed heart disease during the previous two years. In 1987, the cohort members supplied 33,737 sets of toenail clippings; these were stored for subsequent analyses of trace elements in nested case–control studies. The analysis excluded 1595 men whose reported daily energy intake according to the 1986 semiquantitative food-frequency questionnaire was below 800 kcal per day or greater than 4200 kcal per day or who left 70 or more questions blank on the questionnaire. The men who reported a diagnosis of cancer (other than nonmelanoma skin cancer), myocardial infarction, angina, stroke, coronary-artery bypass surgery, or percutaneous transluminal coronary angioplasty on the 1986 questionnaire were also excluded. This study was approved by the Harvard School of Public Health committee for the protection of human subjects; after participants were informed in writing of the purpose of the study, return of nail specimens by mail was deemed to indicate consent.

Ascertainment of Cases

The participants in the Health Professionals Follow-up Study receive a mailed questionnaire every two years. We searched the Na-

From the Departments of Nutrition (K.Y., E.B.R., M.J.S., W.C.W.) and Epidemiology (E.B.R., C.H., D.S., M.J.S., W.C.W.), Harvard School of Public Health, Boston; the Channing Laboratory, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston (E.B.R., M.J.S., W.C.W.); and the Research Reactor Center, University of Missouri–Columbia, Columbia (J.S.M., V.L.S.).

tional Death Index for deaths among those who did not respond to the questionnaires. Through January 31, 1992, we had received questionnaires from, or confirmed the deaths of, more than 94 percent of eligible participants.[17,18]

Men who had fatal coronary heart disease, nonfatal myocardial infarction, coronary-artery bypass surgery, or percutaneous transluminal coronary angioplasty between the return of toenail clippings in 1987 and January 31, 1992, were considered case patients. A letter was sent to all men who reported a newly diagnosed myocardial infarction on the 1988, 1990, or 1992 follow-up questionnaire to confirm the report and to ask for permission to review their medical records.

A myocardial infarction was confirmed by a study physician using World Health Organization criteria[19] or autopsy reports. Fatal coronary heart disease was considered confirmed if it was listed on the death certificate as the underlying cause and a new diagnosis of coronary heart disease was confirmed by records or interviews. Myocardial infarction was considered the probable cause of death if the medical records could not be obtained but the patient required hospital admission and the diagnosis was corroborated by correspondence or telephone interview of a family member or personal physician. Confirmation of coronary-artery bypass surgery or percutaneous transluminal coronary angioplasty was based on self-report only; hospital records obtained for a sample of 102 men confirmed the procedure for 96 percent of them. Sudden death was considered to be due to coronary heart disease, because most sudden deaths in men are due to myocardial infarction.[17,18] During five years of follow-up between 1987 and January 1992, coronary heart disease developed in 470 participants eligible for this analysis (234 had nonfatal myocardial infarctions; 109 died of coronary heart disease, including 45 who died suddenly; and 127 underwent coronary-artery bypass grafting or percutaneous transluminal coronary angioplasty). For the main analyses, we used the first end point for men with more than one coronary heart disease outcome during follow-up.

For each patient with coronary heart disease, a control subject without coronary heart disease, who was alive at the time the patient received his diagnosis, was chosen randomly from the cohort participants who returned toenail clippings. The patient and the control were matched according to age (within one calendar year), smoking status (current smoker; former smoker, matched according to the number of years since stopping; or nonsmoker [i.e., never smoked]), and the date on which the clippings were returned (within one month). In this analysis we included 442 matched pairs, as well as an additional 28 patients and 22 controls for whom the matched participant had missing data on nail trace-element values or other variables.

Assessment of Exposure

The levels of mercury, selenium, and cadmium in the toenails were analyzed by instrumental neutron-activation analysis at the University of Missouri Research Reactor.[20,21] Before analysis, the toenail clippings were washed in a sonicator with deionized water. Case and control specimens were analyzed together, but in random order, with the case status of the toenail specimens unknown to the laboratory personnel.[21,22] In a quality-control study, the average coefficient of variation was 3.0 percent for selenium, 6.2 percent for mercury, and 14.2 percent for cadmium. Because toenails incorporate mercury during formation but are of different lengths, nail clippings taken from all toes at the same time reflect the incorporation of mercury that has occurred over approximately one year. In a study of nurses, the correlation between mercury levels in nails from the same women collected at an interval of six years was 0.58.[21]

Nutrient intakes were calculated from the 1986 dietary questionnaire.[23] In a food-based validation of the 1986 questionnaire, correlations corrected for week-to-week variation were 0.73 for canned tuna fish and 0.58 for dark-meat fish.[24]

Statistical Analysis

Because the distribution of cadmium levels was skewed to the right, the values were log-transformed to improve normality. The Pearson correlation coefficient for the log-transformed cadmium level and the sample weight was −0.48 ($P<0.001$). Therefore, the cadmium level was adjusted for the weight of the toenail sample with the use of residuals from the regression of log cadmium values on the specimen weight. A constant, the predicted log cadmium level for the mean of sample weight, was added back to the residuals, and the antilog values were then calculated.

Differences in means between patients and controls were tested by paired t-tests after log transformation or by Wilcoxon signed-rank tests. Spearman correlation coefficients were calculated to assess associations between the levels of the metals in the toenails and the consumption of specific foods.

Mercury values were categorized into quintiles on the basis of their distribution among the controls. The association between the level of mercury in the toenails and the risk of coronary heart disease was expressed as the relative risk, estimated as an odds ratio, with the 95 percent confidence interval, when the lowest quintile was used as the reference category. Multiple logistic-regression analysis was used to control for known and potential risk factors. The intake of nutrients and the body-mass index were also grouped into quintiles. Alcohol intake was grouped into four categories: 0.0, 0.1 to 5.0, 5.1 to 30.0, and 30.1 or more grams per day. Age was grouped into six categories: less than or equal to 50, 51 to 55, 56 to 60, 61 to 65, 66 to 70, and 71 or more years. Smoking status was grouped into three categories (never smoked, former smoker, and current smoker), and the current smokers were further grouped into two categories (1 to 24 and 25 or more cigarettes per day).

Conditional and unconditional logistic regression gave similar overall results; therefore, in this paper only the results from the latter method are given, to increase power in the subgroups by using the data from all patients and controls. Tests for trend were conducted by assigning the median value for each quintile to all persons in that group and using these values as a continuous, five-level variable. Interactions between mercury and selenium or cadmium were assessed by stratified analysis and the use of a cross-product term, with both elements as continuous variables. In the stratified analysis, the association between mercury levels and coronary heart disease was assessed separately within three levels of cadmium or selenium. In the evaluation of joint classification, nine categories were generated by grouping the amounts of each trace element into three levels.

RESULTS

The range of mercury levels among the control participants was 0.03 to 14.56 μg per gram. Table 1 shows the proportion of dentists, the level of fish consumption, and potential confounding factors according to the level of mercury in the toenails. The mean (±SD) mercury level was 0.91±1.47 μg per gram in dentists, as compared with 0.45±0.40 μg per gram among nondentists ($P<0.001$ by nonparametric unpaired test). Fish consumption among all participants was higher with higher mercury levels. The median toenail mercury levels were 0.29, 0.34, 0.44, 0.62, and 0.75 μg per gram for increasing quintiles of fish consumption (median intake, 20.7, 26.1, 30.4, 37.2, and 51.0 g per day) (Spearman $r=0.42$, $P<0.001$).

The mean mercury level was similar in the patients and the controls, both among matched pairs (mean, 0.74±1.21 μg per gram for patients and 0.72±1.40

TABLE 1. BASE-LINE (1986) CHARACTERISTICS OF THE CONTROLS ACCORDING TO QUINTILE OF MERCURY LEVEL IN THE TOENAILS.*

CHARACTERISTIC	MEDIAN MERCURY LEVEL IN TOENAILS†					P VALUE‡
	0.15 (0.03–0.21)	0.28 (0.22–0.35)	0.45 (0.36–0.54)	0.67 (0.55–0.86)	1.34 (0.87–14.56)	
	range (median)					
No. of men	85	94	97	97	91	
Median age — yr	61	64	62	60	62	0.22
Median body-mass index§	26.2	24.9	25.8	25.0	24.7	0.02
Dentist — no. (%)	34 (40)	57 (61)	60 (62)	68 (70)	76 (84)	<0.001
Family history of coronary heart disease — no. (%)	3 (4)	10 (11)	12 (12)	4 (4)	6 (7)	0.96
Hypertension — no. (%)	22 (26)	28 (30)	21 (22)	23 (24)	20 (22)	0.37
Hypercholesterolemia — no. (%)	6 (7)	8 (9)	10 (10)	12 (12)	12 (13)	0.15
Diabetes mellitus — no. (%)	3 (4)	2 (2)	2 (2)	4 (4)	7 (8)	0.12
Smoking status — no. (%)						
Never smoked	36 (42)	39 (41)	33 (34)	36 (37)	33 (36)	0.44
Former smoker	33 (39)	45 (48)	48 (49)	45 (46)	45 (49)	0.28
Current smoker	14 (16)	8 (9)	14 (14)	11 (11)	9 (10)	0.65
Unknown	2 (2)	2 (2)	2 (2)	5 (5)	4 (4)	
Median daily intake of food or nutrient						
Fish — g	20.7	26.1	30.4	37.2	51.0	<0.001
Red meat — no. of servings	1.1	0.9	0.9	0.8	0.5	<0.001
Poultry — no. of servings	0.21	0.3	0.3	0.3	0.4	0.02
Fruits and vegetables — no. of servings	4.7	4.8	4.6	5.1	6.0	0.01
Alcohol — g	4.7	6.5	7.5	9.2	10.9	0.006
Vitamin E, including supplements — IU	13.3	14.5	13.7	11.8	18.6	0.76
Dietary fiber — g	19.9	20.5	20.8	19.2	23.0	0.04
Folate, including supplements — μg	391	402	397	386	416	0.75
Median toenail selenium level — μg/g	0.85	0.88	0.85	0.84	0.87	0.88
Median toenail cadmium level — μg/g	0.60	0.60	0.63	0.63	0.69	0.03

*Quintiles of toenail mercury were calculated on the basis of data from the 464 controls. Family history of coronary heart disease was defined as a maternal or paternal history of myocardial infarction before 65 years of age. Data on hypertension, hypercholesterolemia, and diabetes mellitus are from self-reports of diagnosis by a physician.

†Quintile values are medians, expressed in micrograms per gram, with the range in parentheses.

‡P values were calculated by a nonparametric test based on Spearman correlation.

§The body-mass index is the weight in kilograms divided by the square of the height in meters.

μg per gram for controls; P=0.76 by the nonparametric paired test) and among all patients and controls (mean, 0.72±1.40 μg per gram for the 470 patients and 0.74±1.21 μg per gram for the 464 controls; P=0.36 by the nonparametric unpaired test). The relative risks of coronary heart disease according to quintile of toenail mercury level are shown in Table 2. After adjusting for age, smoking, and other risk factors for coronary heart disease, we found no evidence of an increased risk of coronary heart disease with higher mercury levels. Furthermore, inclusion of n−3 fatty acid intake from fish in the multivariate model did not change the relative risks appreciably.

Toenail cadmium levels were not associated with the risk of coronary heart disease (P for trend=0.18) after adjustment for age, smoking, alcohol intake, presence or absence of a family history of coronary heart disease, high blood pressure, hypercholesterolemia, and diabetes, and body-mass index (the relative risks [and 95 percent confidence intervals] for increasing quintiles of cadmium were 1.00, 0.95 [0.62 to 1.45], 1.11 [0.72 to 1.71], 0.98 [0.64 to 1.52], and 1.31 [0.85 to 2.03]). For men in the highest category of both mercury and cadmium levels (in which the risk was hypothesized to be the greatest), the relative risk, as compared with those who were in the lowest categories of both, was 1.18 (95 percent confidence interval, 0.68 to 2.04). The interaction was not significant (P=0.87).

Table 3 shows the relative risks of coronary heart disease according to toenail mercury levels within three roughly equal categories of toenail selenium level (low, medium, and high). The toenail mercury levels within the low and medium selenium categories were not significantly associated with the risk of coronary heart disease. Within the highest nail selenium category,

TABLE 2. RELATIVE RISK OF CORONARY HEART DISEASE DURING THREE YEARS OF FOLLOW-UP ACCORDING TO TOENAIL MERCURY LEVELS IN 934 SUBJECTS.

MEASURE*	QUINTILE OF MERCURY LEVEL					P FOR TREND†
	1	2	3	4	5	
Mercury level in toenails — μg/g						
Median	0.15	0.28	0.45	0.67	1.34	
Range	0.03–0.21	0.22–0.35	0.36–0.54	0.55–0.86	0.87–14.56	
No. of patients (n=470)	101	93	90	90	96	
No. of controls (n=464)	85	94	97	97	91	
Age- and smoking-adjusted RR (95% CI)‡§	1.00	0.83 (0.55–1.25)	0.77 (0.51–1.16)	0.77 (0.51–1.16)	0.87 (0.57–1.31)	0.83
Multivariate RR (95% CI)‡¶	1.00	0.92 (0.60–1.41)	0.80 (0.52–1.24)	0.92 (0.60–1.41)	0.97 (0.63–1.50)	0.78
Multivariate RR (95% CI)‡‖	1.00	0.93 (0.60–1.43)	0.83 (0.53–1.30)	0.96 (0.62–1.51)	1.03 (0.65–1.65)	0.55

*RR denotes relative risk, and CI confidence interval.

†The P value was calculated from a test for trend across quintiles.

‡The lowest quintile of toenail mercury level served as the reference category.

§Values have been adjusted for age (six categories: ≤50, 51 to 55, 56 to 60, 61 to 65, 66 to 70, and >70 years) and smoking status (four categories: never smoked, former smoker, 1–24 cigarettes daily, and >24 cigarettes daily).

¶Values have been adjusted for age (six categories: ≤50, 51 to 55, 56 to 60, 61 to 65, 66 to 70, and >70 years), smoking status (four categories: never smoked, former smoker, 1 to 24 cigarettes daily, and >24 cigarettes daily), alcohol intake (four categories: 0, 1.0 to 5.0, 5.1 to 30.0, and >30.0 g per day), family history of coronary heart disease (binary), high blood pressure (binary), hypercholesterolemia (binary,) diabetes (binary), body-mass index (five categories) at the 1986 base line, and quintile of toenail sample weight.

‖Values have been adjusted for the covariates listed above and also for quintiles of intake of n−3 fatty acids (eicosapentaenoic acid and docosahexaenoic acid).

men with the highest mercury level had a higher risk of coronary heart disease than those with the lowest mercury level; however, the result of the test for trend did not attain statistical significance. The subjects were also divided into three groups according to levels of mercury, as well as according to selenium levels. For men in the highest category for mercury and the lowest category for selenium, in which the risk was hypothesized to be the greatest, the multivariate relative risk, as compared with those in the lowest category for mercury and the highest category for selenium, was 0.99 (95 percent confidence interval, 0.57 to 1.72), after age and other risk factors were controlled for (P for interaction=0.89).

In separate multivariate analyses, the relative risk of nonfatal myocardial infarction or fatal coronary heart disease for men in the highest versus the lowest quintile of mercury level was 1.04 (95 percent confidence interval, 0.65 to 1.68; P for trend=0.68), and for coronary-artery bypass grafting or percutaneous transluminal coronary angioplasty, the relative risk was 0.96 (95 percent confidence interval, 0.48 to 1.90; P for trend=0.65).

The form of mercury in fish is primarily methylmercury, and that to which dentists are occupationally exposed is elemental mercury. Because it is possible that different forms of mercury may have different effects on cardiovascular risk, we repeated our analyses after excluding dentists. Although the statistical power was substantially reduced (220 cases), we observed a nonsignificant association with the toenail mercury level. The multivariate relative risk for the highest (0.84 μg per gram) versus the lowest (0.13 μg per gram) quintile of mercury was 1.27 (95 percent confidence interval, 0.62 to 2.59; P for trend=0.43); with additional control for intake of eicosapentaenoic acid plus docosahexaenoic acid, the relative risk was 1.70 (95 percent confidence interval, 0.78 to 3.73; P for trend=0.41).

DISCUSSION

Among the participants in this study, dentists and those who ate more fish had significantly higher levels of mercury in their toenails. However, our data do not support an association between mercury levels and an increased risk of coronary heart disease, as has been reported previously[5] and also in a study reported in this issue of the *Journal*.[25] The absence of any clear association is probably not due to methodologic bias, because this study used a nested case–control design within a large prospective cohort, and because the toenail specimens were collected prospectively before the

TABLE 3. RELATIVE RISK OF CORONARY HEART DISEASE DURING THREE YEARS OF FOLLOW-UP ACCORDING TO TOENAIL MERCURY AND SELENIUM LEVELS AMONG PATIENTS AND CONTROLS.

MEASURE*	QUINTILE OF MERCURY LEVEL					P FOR TREND†
	1	2	3	4	5	
Low selenium (range, 0.49–0.81 μg/g)‡						
No. of controls (n=159)	28	27	37	37	30	
No. of patients (n=153)	37	29	23	33	31	
Multivariate RR (95% CI)§¶	1.00	0.99 (0.45–2.16)	0.51 (0.23–1.12)	0.78 (0.37–1.63)	1.00 (0.46–2.20)	0.70
Medium selenium (range, 0.81–0.94 μg/g)‡						
No. of controls (n=157)	26	33	32	31	35	
No. of patients (n=153)	33	28	31	31	30	
Multivariate RR (95% CI)§¶	1.00	0.65 (0.30–1.43)	0.72 (0.33–1.56)	0.96 (0.45–2.08)	0.65 (0.30–1.44)	0.50
High selenium (range, 0.94–5.00 μg/g)‡						
No. of controls (n=148)	31	34	28	29	26	
No. of patients (n=164)	31	36	36	26	35	
Multivariate RR (95% CI)§¶	1.00	1.58 (0.73–3.46)	1.82 (0.81–4.12)	1.69 (0.71–4.03)	2.47 (1.01–6.04)	0.12

*RR denotes relative risk, and CI confidence interval.

†The P value was calculated by a test for trend across quintiles.

‡The range includes both the patients and controls.

§The lowest quintile of toenail mercury level served as the reference category.

¶Values have been adjusted for age (six categories: ≤50, 51 to 55, 56 to 60, 61 to 65, 66 to 70, and >70 years), smoking status (four categories: never smoked, former smoker, 1 to 24 cigarettes daily, and >24 cigarettes daily), alcohol intake (four categories: 0, 1.0 to 5.0, 5.1 to 30.0, and >30.0 g/day), family history of coronary heart disease (binary), high blood pressure (binary), hypercholesterolemia (binary), diabetes (binary), body-mass index (five categories) at the 1986 base line, and continuous toenail sample weight.

coronary heart disease events occurred. The absence of an association between mercury levels and coronary heart disease could be due to a limited range of mercury exposure. It is also possible that mercury levels in nails are not a good indicator of long-term mercury intake. However, the strong relation between mercury levels in nails and the intake of fish, as measured by a food-frequency questionnaire, and the much higher levels in dentists than nondentists support the validity of mercury levels in nails as a measure of exposure. Because of the occupational exposure of dentists, the range of mercury levels was greater than would be seen in the general U.S. population. Toenail mercury levels have previously been demonstrated to be a valid measure of dietary mercury exposure.[26] Nail mercury levels also provided an indicator of the long-term body burden of mercury among women in the Nurses' Health Study.[21]

We speculated that there might be some beneficial effects of n−3 fatty acids in fish that could counterbalance the effect of mercury. However, the multivariate analysis that controlled for n−3 fatty acid intake did not change the relative risks appreciably. Furthermore, in the same Health Professionals Follow-up Study cohort, increasing fish intake (from one to two servings per week to five to six servings per week) was not associated with the overall incidence of coronary heart disease, although an inverse trend was seen with the small number of sudden deaths.[27] The positive association between fish consumption and the risk of coronary heart disease in the Finnish study[5,28] could be due to differences in the nutrient composition of the fish, unique contaminants, or different risk-factor characteristics among fish eaters. The concentrations of mercury in hair from subjects in the Finnish study and in toenails from the recent European study[25] are similar to or lower than those reported in our study.

The form of mercury consumed in fish is primarily methylmercury, and that due to the occupational exposure of dentists is primarily elemental mercury. As indicated by the strong associations with toenail mercury concentrations in our study, both forms of mercury are absorbed, and both can have serious neurologic toxic effects.[29] However, there are some differences in the clinical and pathological manifestations of neurologic toxicity from these two forms of mercury, so the possibility exists that they might influence the risk of cardiovascular disease differently. We found a positive but nonsignificant association between mercury levels and the risk of coronary heart disease in an analysis excluding dentists.

The marginally significant increased risk of coronary heart disease associated with higher mercury levels among men in the highest third of the group with re-

spect to selenium level was probably due to chance, because the combination of high mercury and low selenium levels was not associated with excess risk. The higher proportion of current smokers in the lowest mercury-level category in this study is probably due to the participants' lifestyles, because health-oriented men may eat more fish in addition to not smoking.

In conclusion, toenail mercury levels measured by neutron activation reflect occupational exposure of dentists and intake of fish. However, we found no evidence, over a wide range of mercury exposures, that the overall levels were associated with any substantial increase in the risk of coronary heart disease. Furthermore, we found no increase in risk of coronary heart disease associated with higher mercury levels in combination with low selenium or high cadmium levels. However, a weak relation between mercury exposure, particularly from fish consumption, and the risk of coronary heart disease cannot be excluded.

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Regulatory Impact Analysis of the Final Clean Air Mercury Rule

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Regualtory Impact Analysis of the Final Clean Air Mercury Rule

U.S. Environmental Protection Agency
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APPENDIX C CARDIOVASCULAR EFFECTS AND METHYLMERCURY C-1
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APPENDIX C

CARDIOVASCULAR EFFECTS AND METHYLMERCURY

C.1 Introduction

Some recent epidemiological studies suggest that methylmercury may be a risk factor for myocardial events, such as acute myocardial infarction (AMI), coronary heart disease (CHD), cardiovascular disease (CVD) or other adverse cardiovascular effects such as carotid atherosclerosis, increased blood pressure, or decreased heart rate variability. Other recent studies did not observe a relationship between methylmercury levels and myocardial events.[1]

This appendix presents a qualitative discussion of recent studies that have looked at the relationship between potential for cardiovascular impacts from chronic low-dose methylmercury exposures. The results of several key peer-reviewed studies are summarized and study uncertainties and other relevant information are also discussed. This section also includes a discussion of the beneficial effects of fish consumption.

The potential for adverse cardiovascular effects due to consumption of fish containing methylmercury is of particular interest given the evidence for the *protective* cardiovascular effect believed to occur from an increased dietary fish intake. Strong evidence indicates that consumption of fish, particularly fatty fish, has a cardio-protective effect (Wang et al. 2004; 2005 Dietary Guidelines Advisory Committee 2004; NRC 2000). The presence of omega-3 (*n*-3) fatty acids in fish oils is hypothesized to drive the preventive effect on cardiovascular disease (Calder 2003). Several mechanisms of action are recognized, including the stabilization of the atherosclerotic plaque (which, when ruptured, may cause a heart attack) by reducing the infiltration of inflammatory and immune cells (lymphocytes and macrophages) into the plaque. However, those studies relevant to the general population show cardiovascular health benefits were for fish in the diet, not for isolated omega-3 fatty acids, such as in fish oil supplements, suggesting the potential for synergistic benefits. Thus, consumption of fish containing methylmercury is not necessarily detrimental even though some evidence suggests that the cardiovascular system may be a target system for methylmercury exposure. The cardio-protective effect of fish consumption has not been observed in all studies (Curb and Reed 1985; Morris et al. 1992; Folsom and Demissie 2004).

C.2 Acute Myocardial Infarctions and Major Cardiovascular Effects

Salonen et al. (1995), Virtanen et al. (2005), and Guallar et al. (2002) have reported an association between increased risk of AMI (or other major cardiovascular impacts) and exposures to methylmercury via fish consumption or mercury levels in the body. The findings of these studies are summarized in this section.

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[1] As described in detail by NRC (2000) and elsewhere, consumption fish containing methylmercury is the primary route of exposure to methylmercury.

C.2.1 The Kuopio Ischemic Heart Disease Risk Factor Study (KIHD) Cohort

Salonen et al. (1995) investigated the association between methylmercury and AMI in a study of a subset of men from the KIHD study group (n = 1,833 Finnish males age 42 to 60 years). Rissanen et al. (2000) in a follow up to this study extended observation of the same cohort and Virtanen (2005) also utilized this cohort. In theory, the findings could be specific only for men in Eastern Finland, who traditionally have a high intake of meat, fish and saturated animal fat and a low intake of selenium and vitamin C and, most likely, other vegetable-derived antioxidants. However these studies provide new information about potential mechanisms in how methylmercury interacts with the cardiovascular system in humans, even though the consequences of methylmercury intake for the cardiovascular system may vary among populations due to different confounding factors (Salonen et al. 1995).

In the Salonen et al. (1995) study, all subjects' mercury levels were evaluated by hair analysis, and subjects were grouped into three exposure groups according to hair mercury levels. Urinalysis was also conducted for a subset of men who either had an AMI during the follow-up or acted as the controls to that subset. Fish consumption was measured through an interview-checked four-day food recording. Daily fish intake ranged from 0 to 619.2 g/day, and hair concentrations ranged from 0 to 15.67 ppm (μg/g). Stern (2005) observes that the estimated mean dietary methylmercury intake was 7.6 ug/day, which is only somewhat larger than the intake corresponding to the EPA RfD for a 70-kg (average) man of 7.0 ug/day (the corresponding mean hair mercury concentration was 1.92 μg/g (ppm) (Stern 2005). For the subset of men who had an AMI, two control subjects were matched to each patient according to age, municipality of residence, and date of baseline examination. Occurrence of AMI and deaths due to CHD and CVD were recorded over the course of a seven-year period. In the analysis of the results, Salonen et al. found that "the hair mercury (r = .27) and the urinary mercury (r = .47) correlated with the estimated fish intake." Men with the highest hair mercury content (≥ 2.0 μg/g and ranging up to 15.67 μg/g - Stern (2005) estimates that ≥ 2.0 μg/g is likely equivalent to the 90th percentile in U.S. men) had twice the risk of AMI when compared to men in the two lowest exposure groups when adjusting for age, examination year, ischemic exercise, electrocardiogram (ECG), and maximal oxygen uptake (relative risk [RR] 2.0; 95% confidence interval [CI] 1.2-3.1). The risk of AMI decreased slightly for men within the highest hair mercury category (≥ 2.0 μg/g) after adjusting for all confounders and risk factors[2] but was still statistically significant (RR = 1.7; 95% CI 1.03-2.8). The relative risk was similar for coronary deaths but not statistically significant due to the smaller number of events. However, men in this group also had elevated risks of cardiovascular death (RR = 2.9; 95% CI 1.2-6.6) and death by all causes (RR 2.3; 95% CI 1.4-3.6) after adjusting for all confounders and risk factors. Urinary mercury levels were also significantly (and independently) associated with risk of AMI after adjusting for the strongest risk factors (for each μg mercury excreted daily, the risk of AMI increased by 36%; 95% CI 1% to 82%). Based on these results, the study authors conclude that, "although consumption of fish may be healthy in general, some fish may contain agents that are

[2] Risk factors included age, examination year, ischemic exercise ECG, maximal oxygen uptake, family history of CHD, cigarette-years, mean systolic blood pressure, diabetes, socioeconomic status, place of residence (urban vs. rural), dietary iron intake, and serum apolipoprotein B, HDL_2 cholesterol, and ferritin concentrations.

not healthy for the human cardiovascular system." Further, the authors suggest that mercury is a risk factor for coronary and fatal CVD.

Two relevant follow-up studies have been conducted on the men in the KIHD population. Rissanen et al. (2000) examined the interaction of mercury and the serum *n*-3 end-product fatty acids docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA). For this analysis, the men in the KIHD cohort study were divided into quintiles based on their level of serum fatty acids. Risk of acute coronary events was examined within the study cohort as a function of *n*-3 fatty acid levels. After adjusting for other risk factors,[3] men in the highest fifth (quintile) of *n*-3 fatty acid level exhibited a 44 percent reduced risk of acute coronary events (95% CI 11% to 65%) when compared to the lowest quintile. When the data were stratified by hair mercury concentration into those with hair mercury content above and below 2 μg/g, individuals with lower hair mercury who were also in the upper quintile of *n*-3 fatty acid level had a 67 percent reduced risk of acute coronary events (95% CI 19% to 87%) compared with men with higher hair mercury who were also in the upper quintile of *n*-3 fatty acid level. In each quintile, subjects with the higher hair mercury concentrations had a higher risk of acute coronary events, suggesting that the cardio-protective effects of the serum fatty acids was attenuated by the mercury. Based on these results, Rissanen et al. suggest that their data "provide for the concept that fish-oil derived fatty acids reduce the risk of acute coronary events. However, a high mercury concentration in fish could attenuate this protective effect."

In a more recent follow-up study of the KIHD cohort, the association between mercury and the risk of acute coronary events and mortality from CVD, CHD, and all causes was re-evaluated in a group of 1,887 men (Virtanen et al. 2005). The study also examined whether mercury could interfere with the beneficial effects of fish oils. The interaction between mercury and the serum *n*-3 end-product fatty acids DHA, DPA, and eicosapentaenoic acid was investigated. Deaths by CVD, CHD, and all-causes were recorded, and fish consumption was measured through an interview-checked 4-day food recording. Fish intake in men for those in the highest third (tertile) of hair mercury content was more than double that of the lowest tertile (65 vs. 30 g/day, respectively). High mercury content in hair was also most strongly associated with fish intake and serum DHA plus DPA concentrations. Men in the highest tertile of hair mercury content (>2.03 μg/g) had an increased risk for frank cardiovascular effects, including AMI (RR 1.60; 95% CI 1.24-2.06), CVD (RR 1.68; 95% CI 1.15-2.44), CHD (RR 1.56; 95% CI 0.99 to 2.46), and any death (RR 1.38; 95% CI 1.15-1.66), compared with men in the combined lower two thirds.[4] For each microgram of mercury in hair, the risk of acute coronary events increased, on average, by 11 percent (95% CI 6% to 17%). Based on these results, Virtanen et al. concluded that "high content of mercury in hair may be a risk factor for acute coronary events

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[3] Risk factors included age, examination years, body mass index, maximal oxygen uptake, hair mercury content, serum ferritin, serum LDL cholesterol, systolic blood pressure, serum insulin, ADP-induced platelet aggregation, socioeconomic status, ischemic findings in exercise test, smoking, place of residence, and dietary energy intake.

[4] Estimated increased risks were adjusted for age, examination year, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol, body mass index (BMI), family history of ischemic heart disease, systolic blood pressure, maximal oxygen uptake, urinary excretion of nicotine metabolites, serum selenium, alcohol intake, serum DHA + DPA as a proportion of all fatty acids in serum, and intake of saturated fatty acids, fiber, and vitamin C and E.

and CVD, CHD, and all-cause mortality in middle-aged eastern Finnish men." Furthermore, the authors concluded that "mercury may also attenuate the protective effects of fish on cardiovascular health."

C.2.2 The European Multicenter Case Control Study on Antioxidants, Myocardial Infarction and Cancer of the Breast (EURAMIC) Cohort

In a case-control study using subjects from the EURAMIC study population (n = 1,400 men from eight European countries and Israel), Guallar et al. (2002) investigated the relationship between the risk of a first myocardial infarction in men and mercury levels measured in toenail clippings[5] and DHA levels in adipose tissue. The investigators reported that mercury levels in patients who had suffered AMI were 15 percent higher (after adjusting for DHA level and coronary risk factors) than levels in controls. Additionally, men in the highest quintile of mercury exposures exhibited a risk-adjusted[6] 2.16-fold increased risk (odds ratio [OR]) of myocardial infarction (95% CI 1.09-4.29) when compared to the lowest quintile. DHA level also was inversely associated with the risk of myocardial infarction after adjusting for mercury level (OR 0.59; 95% CI 0.30-1.19). Consequently, toenail mercury level was directly associated with the risk of myocardial infarction and adipose tissue DHA level was inversely associated with the risk. One study location, which had higher mercury than the others, appeared to be influential in the analysis. Guallar et al. concluded that "high mercury content may diminish the cardio-protective effect of fish intake."

C.2.3 Mechanisms for Cardiovascular Impacts

Currently, there is a general lack of mechanistic evidence for the role of methylmercury in heart disease (Stern 2005). However, Salonen et al. (1995), Virtanen (2005), and Guallar et al. (2002) summarize several mechanistic bases by which mercury may increase the risk of adverse cardiovascular impacts. The increased risk may be related to a reduction in the body's antioxidative capacity and the promotion of free radical stress and lipid peroxidation. A reduction in antioxidative capacity may be due to the high affinity of mercury for sulfhydryl groups (thereby inactivating antioxidative thiolic compounds) and mercury's tendency to bind to selenium and form an insoluble complex (selenium is believed to be a factor in catalyzing the formation of free-radical scavengers). Mercury is a transitional metal and therefore can promote the formation of free radicals via Fenton-type reactions. Additionally, Virtanen et al. (2005) note that mercury inactivates paraoxonase, an extracellular enzyme that may help prevent AMI. Mercury may also may promote ADP-induced platelet aggregation and blood coagulation, inhibit endothelial-cell formation and migration, and affect apoptosis (i.e., programmed cell death) and inflammatory responses.

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[5] It should be noted that although measuring mercury exposure through toenail clippings appears to quantitatively reflect dietary intake, this method has not been well characterized in comparison to hair or blood mercury exposure. Consequently, it is not possible to distinguish elemental mercury exposure from that of methyl mercury (Stern 2005). Additionally, results from this study cannot be compared to those that measure mercury through hair or blood.

[6] Adjusted for age, DHA, BMI, waist:hip ratio, smoking status, alcohol intake, high-density lipoprotein cholesterol, diabetes, history of hypertension, parental myocardial infarction, α-tocopherol level, ß-carotene level, toenail selenium level, and toenail weight.

C.2.4 Other Studies Evaluating CVD and Mercury Levels

In contrast with the aforementioned studies that may demonstrate a correlation between methylmercury and AMI, CHD, and CVD, Yoshizawa et al. (2002) conducted a study specifically addressing the relationship between total mercury exposure and the risk of coronary heart disease, and reported no significant association. This study utilized the Health Professionals Follow-up Study as its study population and examined a subset of 470 patients, including men who had fatal coronary disease, nonfatal myocardial infarction, coronary-artery bypass surgery, or percutaneous transluminal coronary angioplasty, as well as controls. Mercury levels were measured via toenail clippings. After adjusting for age, smoking and other risk factors, toenail mercury was not associated with the risk of coronary heart disease (CHD). Adjustment for intake of *n*-3 fatty acids from fish did not appreciably change these results. When dentists were excluded from the analysis, an association of toenail mercury with CHD was observed by comparing the highest and lowest quintiles of mercury exposure (RR 1.27; 95% CI 0.62-2.59; *P* for trend = 0.43) (Yoshizawa et al. 2002). This relationship, however, was not statistically significant (possibly due to the 53 percent reduction in total number of cases, to 220), suggesting that further study with a larger sample may be warranted.

In a recent review of the cardiovascular health effects of methylmercury, Stern (2005) noted that interpretation of the Yoshizawa results may depend on whether it is hypothesized that total mercury exposure or specifically methylmercury exposure is responsible for the cardiovascular effects of mercury. If only methylmercury is responsible for cardiovascular effects then the elevated exposure to elemental mercury of dentists would tend to confound the underlying association of methylmercury and cardiovascular effects. Stern (2005) also notes that the strengthening of the association when an adjustment is made for n-3 fatty acids is consistent with the observations in other studies that overall risk occurs as a balance between the protective effect of n-3 fatty acids from fish and the adverse effects from methylmercury.

In a study that focused on inorganic mercury exposure from dental amalgams, Ahlqwist et al. (1999) examined associations between serum mercury and myocardial infarctions (among other health outcomes), among 1,462 Swedish women (ages 38 to 60 at study initiation) for 25 years. Mercury concentration in serum was measured in all subjects at the beginning of the study and, 13 years later, for a subsample of 142 women from one age group (all born in 1922). No statistically significant association between serum mercury and MI was found. However, Stern (2005) notes that it is difficult to assess the significance of these findings for methylmercury exposures that occur through fish consumption as serum mercury disproportionally reflects inorganic mercury exposure.

In a case-control study of both men and women with a first-time MI from a longitudinal cohort in northern Sweden (n=78), Hallgren et al. (2001) analyzed erythrocyte mercury concentration in order to study a possible association between increased fish consumption and reduced coronary heart disease (concentration of mercury in erythrocytes is often used as an index of fish consumption). The researchers summed the *n-3* fatty acids, EPA and DHA, to express the percentage of total plasma polyunsaturated fatty acids (P-PUFA). Mean levels of mercury in erythrocytes were reported as 4.44 ng/g in cases and 5.42 ng/g in controls. Stern (2005) notes that these concentrations translate to about 2.8 and 3.4 ng/L, respectively, for

mercury concentrations in whole blood. Hallgren et al. (2001) concluded that erythrocyte mercury concentration alone was not significantly associated with the occurrence of MI but found that higher levels of P-PUFA's and erythocyte mercury (which was used as a marker of fish intake) are significantly associated with lower risk of myocardial infarction. Various combinations of high and low P-PUFA and high and low mercury concentration were assessed, and none of the combinations had a statistically significant odds ratio (OR) greater than 1.0, including the group of subjects with high mercury and low P-PUFA that might be expected to have a higher risk of heart disease. The high mercury-low P-PUFA group did have an OR greater than 1.0, but this group consisted of only four individuals and the result was not considered statistically significant.

In two studies of death certificates in the region near Minamata City, Japan, Tamashiro et al. (1984 and 1986) investigated the significance of heart disease as a primary or secondary cause of death. Tamashiro et al. (1984) studied the causes of death among those with official diagnoses of Minamata disease in a region including Minamata City in two groups: those who died from 1954 to 1969 (n=44), and those who died from 1970 to 1980 (n=334). In the first group, Minamata disease and diseases of the central nervous system were the underlying causes of death, but nonischemic heart disease accounted for 50 percent of the secondary causes of death (multiple causes of death could be reported). Analysis of the second group constituted a case-control study by matching individuals with a control in the same city or town by age, sex, and year of death. In no disease were the ORs observed to be significantly high or low. However, when non-Minamata diseases and Minamata diseases were mentioned on the same death certificate, non-ischemic heart disease (for males and females combined) was the only statistically significant cause of death for this second group.

Tamashiro et al. (1986) also investigated the causes of death from death certificates in the Minamata City area, but focused on fishermen and their families residing in a small coastal area of the city. Certificates from 1970 to 1981 were examined and standard mortality rates (SMRs) were calculated using age-specific death rates for Minamata City as a standard. The results showed that SMRs for all categories of heart disease and hypertensive disease were not significantly elevated in the study population. Stern (2005) note several uncertainties associated with these results. He notes that deaths from methylmercury-related cardiovascular death could have possibly peaked prior to 1970, even though incidence of "Minamata disease" was observed to peak after this date in the study area (thus the selection of the study time period). The exposure to methylmercury may have varied throughout the study area, and death rates in Minamata City itself were used as the denominator in calculating the SMRs. Therefore, although overall deaths were more prevalent in this study area, lower exposures to methylmercury that resulted in higher rates of heart disease could have occurred. Furthermore, there were no data reported on the type of fish consumed and the relative consumption of *n-3* fatty acids which may provide protection against the cardiovascular effects of methylmercury. Stern (2005) also notes in his review that differences in the results from the two studies by Tamashiro et al. are probably related to study design, and the weaknesses of the Tamishiro 1986 study likely explain the differences in the studies with respect to the identification of heart diseases as potentially associated with highly elevated methylmercury exposures resulting in Minamata disease. Stern also notes that for ischemic heart disease only males appear to be at risk.

C.3 Other Cardiovascular Effects

Another possible adverse cardiovascular effect related to methylmercury exposure is accelerated progression of carotid atherosclerosis (i.e., the progressive narrowing and hardening of the arteries over time). This effect was observed in men from the KIHD study population, in which high hair mercury content was the second strongest predictor for the four-year increase in the mean intima-media thickness (IMT), a marker of early artherosclerosis (Salonen et al. 2000). Predictors for IMT ranked as follows: systolic blood pressure > hair mercury content> antidyslipidemic medication> dietary iron intake > cigarette pack years > age. Additionally, there was an 8 μm incremental increase in the four-year IMT for each μg/g increase in hair mercury content.

The case for mercury-induced blood pressure effects is not as strong, but some evidence suggests a possible link between methylmercury exposure and hypertension and heart rate variability. Oka et al. (2003) reviewed electrocardiogram data, along with blood pressure and pulse pressure measurement, in Minamata patients who had been exposed to methylmercury *in utero* and were institutionalized for "fetal Minamata disease" as adults. Subjects had a significantly elevated resting heart rate and a slightly (but not significantly) decreased variability in heart rate when compared to controls. Blood pressure did not differ between the two groups, but pulse pressure was significantly decreased among the subjects. Considering the limited data available, it is difficult to draw any conclusions at this time regarding heart rate variability and methylmercury exposure; more research is necessary to fully explore this area.

Cardiovascular effects have also been reported for children. A decrease in heart rate variability, an important measure of the ability of the cardiovascular system to withstand stress, was reported for children in the Faroe Islands (917 seven-year-old children) exposed *in utero* to methylmercury through maternal consumption of fish and marine mammals (additional post-natal exposures, again though consumption of fish and marine mammals may have also occurred). At seven years, children who had been exposed before birth to higher levels of cord blood mercury (up to 10 μg/L) had increased blood pressure as well as a decrease in heart rate variability (Sorensen et al. 1999). Blood pressure was based upon a single measure for each child. At fourteen years, the effect on blood pressure in this cohort was no longer observed but heart rate variability remained low (Grandjean et al. 2004). It is unclear, however, whether this effect will persist beyond age 14 and what the significance of this finding is for adverse health outcomes later in life.

A recent study by Vupputuri et al. (2005) showed no statistically significant association between total blood mercury and blood pressure in a sample of 1,240 women aged 16 to 49 years from the National Health and Nutrition Examination Survey 1999-2000. Additionally, no association was observed between total blood mercury and blood pressure in fish consumers when data were stratified by dietary fish intake (subjects were separated into those who consume fish and those who consume no fish).[7] More research is required to reduce the uncertainty

[7] A weak association was observed, however, between total blood mercury and blood pressure among subjects who did *not* consume any fish (i.e., systolic blood pressure increased by 1.83 mm mercury per 1.3 μg/L increase in total blood mercury; 95% CI 0.36-3.30; $P = 0.018$; adjusted for age, race, income, body mass index, pregnancy status, and dietary sodium, potassium, and total calories). Vupputuri et al. (2205) suggest that the oils in fish may counteract

associated with the possibility of other cardiovascular effects, including blood pressure, from exposure to methylmercury in both adults and children. A potential confounding effect in several of the dietary studies could be based on method of preparation of fish (Mozaffarian et al. 2004).

C.4 Cardiovascular Health Benefits of Fish Consumption

Current federal dietary recommendations about fish consumption are found in the 2005 Dietary Guidelines for Americans (DHHS and USDA 2005). The Guidelines were based on an expert scientific report from the 2005 Dietary Guidelines Advisory Committee (2005 Dietary Guidelines Advisory Committee 2004). The Advisory Committee report in turn references two major sources: the National Academy of Sciences Institute of Medicine (IOM) report on Dietary References Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (IOM 2002) and the DHHS Agency for Healthcare Research and Quality (AHRQ) evidence-based AHRQ Report Effects of Omega-3 Fatty Acids on Cardiovascular Disease (Wang et al. 2004). The main conclusions of the IOM and AHRQ reports are summarized below. The Advisory Committee also identified the main conclusions of six other national and international expert groups regarding recommendations for fish consumption.

Available evidence suggests that the cardiovascular health benefits of fish consumption are related to the long chain omega-3 polyunsaturated fatty acids in fish (LC omega-3 PUFA, also called LC omega-3 PUFA), which are unique nutrients in fish. The specific omega-3 fatty acids are docosahexaenoic acid (DHA) and eicosahexaenoic acid (EPA). In the general population (rather than in heart patients), most of the studies were observational (epidemiologic) studies of fish consumption and cardiovascular disease and not studies of omega-3 fatty acid supplements (for example, see Wang et al. 2004 and FDA 2004). Therefore, although evidence indicates that the cardiovascular health benefits of fish consumption are related to the omega-3 fatty acids in fish oil, DHA and EPA, the actual studies, relevant to the general population, showing cardiovascular health benefits were for fish in the diet, not for fish oil supplements. According to the Dietary Guidelines, the current federal dietary recommendations are that most fats should come from sources of polyunsaturated and monounsaturated fatty acids, such as fish, nuts and vegetable oils. Based on the scientific review of the Advisory Committee, the Dietary Guidelines note that limited evidence suggests an association between consumption of fatty acids in fish and reduced risks of mortality from cardiovascular disease for the general population. Other sources of EPA and DHA may provide similar benefit; however, more research is needed. The Dietary Guidelines further state that "evidence suggests that consuming approximately two servings of fish per week (approximately 8 ounces total) may reduce the risk of mortality from coronary heart disease and that consuming EPA and DHA may reduce the risk of mortality from cardiovascular disease in persons who have already experienced a cardiac event." The Dietary Guidelines explain that the Food and Drug Administration and EPA are advising women of childbearing age who may become pregnant, pregnant women, nursing mothers, and young children to avoid some types of fish and shellfish and to eat fish and shellfish that are lower in mercury, and refer readers to the FDA telephone hotline and web site.

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the potentially harmful effects of mercury on blood pressure.

The scientific review by the Dietary Guidelines Advisory Committee on fish consumption used as its starting point the comprehensive Institute of Medicine report on macronutrients (IOM 2002). The IOM report found that "a growing body of literature suggests that diets high in EPA and DHA may afford some degree of protection against CHD." The Advisory Committee review also relied upon an evidence-based review by AHRQ (Wang et al. 2004). The AHRQ report evaluated 22 prospective cohort studies that were conducted in the US and other developed countries. AHRQ noted that most of the cohorts had several thousand subjects; the range was 272 to 223,170 subjects, with most subjects at least age 40. AHRQ indicated that, despite some limitations, if viewed together, these studies provide evidence that is highly applicable to the U.S. population. Overall, AHRQ found that the evidence from the primary and secondary prevention studies supports the hypothesis that the consumption of omega-3 fatty acids, fish, and fish oil reduces all-cause mortality and various cardiovascular disease (CVD) outcomes. These outcomes include sudden death and cardiac death (coronary or myocardial infarct (MI) death). Thus, the AHRQ report concluded that the consumption of omega-3 fatty acids from fish or from supplements of fish oil reduces all-cause mortality and various CVD outcomes. Additionally, the Advisory Committee based its conclusions on its own analysis of epidemiologic studies of the cardioprotective effects of fish consumption among healthy populations, such as those by Dolecek (1992), Siscovick et al. (1995), Hu et al. (2002), and Mozaffarian et al. (2003) (cited in Dietary Guidelines Advisory Committee 2004).

FDA in 2004 (FDA 2004) announced the availability of a qualified health claim for reduced risk of coronary heart disease (CHD) on conventional foods that contain EPA and DHA omega-3 fatty acids. The FDA explained that, typically, EPA and DHA omega-3 fatty acids are contained in oily fish, such as salmon, lake trout, tuna and herring. FDA also stated that these fatty acids are not essential to the diet; however, scientific evidence indicates that these fatty acids may be beneficial in reducing CHD. An example of wording of the qualified health claim as it would appear on a food label would be, "Supportive but not conclusive research shows that consumption of EPA and DHA omega-3 fatty acids may reduce the risk of coronary heart disease. One serving of [name of food] provides [x] grams of EPA and DHA omega-3 fatty acids. [See nutrition information for total fat, saturated fat and cholesterol content.]"

C.5 Conclusions

In summary:

- Studies investigating the relationship between methylmercury and cardiovascular impacts have reached different conclusions. The findings to date and the plausible biological mechanisms warrant additional research in this arena (Stern 2005; Chan and Egeland 2004).

- Some recent epidemiological studies of men suggest that methylmercury is associated with a higher risk of acute myocardial infarction, coronary heart disease and cardiovascular disease in some populations. Other recent studies have not observed this association.

- Some studies have suggested that methylmercury attenuates the beneficial effects of fish consumption. A further possible explanation is that the observed effect

may be present in certain populations but is not generalizable to other populations.

- There is a significant and well-recognized body of literature documenting the cardioprotective benefits of fish consumption.

- As the science on the impact of methylmercury on the risk of cardiovascular events remains uncertain, and the weight of the evidence, in fact, supports a positive association between fish consumption and potential cardiovascular benefits, the impacts of methylmercury from fish consumption are only discussed qualitatively.

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Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000

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Blood organic mercury (i.e., methyl mercury) concentrations among 1,709 women who were participants in the National Health and Nutrition Examination Survey (NHANES) in 1999 and 2000 (1999–2000 NHANES) were 0.6 µg/L at the 50th percentile and ranged from concentrations that were nondetectable (5th percentile) to 6.7 µg/L (95th percentile). Blood organic/methyl mercury reflects methyl mercury intake from fish and shellfish as determined from a methyl mercury exposure parameter based on 24-hr dietary recall, 30-day food frequency, and mean concentrations of mercury in the fish/shellfish species reported as consumed (multiple correlation coefficient > 0.5). Blood organic/methyl mercury concentrations were lowest among Mexican Americans and highest among participants who designated themselves in the Other racial/ethnic category, which includes Asians, Native Americans, and Pacific Islanders. Blood organic/methyl mercury concentrations were ~1.5 times higher among women 30–49 years of age than among women 16–29 years of age. Blood mercury (BHg) concentrations were seven times higher among women who reported eating nine or more fish and/or shellfish meals within the past 30 days than among women who reported no fish and/or shellfish consumption in the past 30 days. Blood organic/methyl mercury concentrations ≥ 5.8 µg/L were lowest among Mexican Americans (2.0%) and highest among examinees in the Other racial/ethnic category (21.7%). Based on the distribution of BHg concentrations among the adult female participants in 1999–2000 NHANES and the number of U.S. births in 2000, > 300,000 newborns each year in the United States may have been exposed *in utero* to methyl mercury concentrations higher than those considered to be without increased risk of adverse neurodevelopmental effects associated with methyl mercury exposure.
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Whole blood total mercury (BTHg) concentrations reflect exposure to organic mercury (OHg), predominantly blood methyl mercury (BMHg) from consumption of fish and shellfish (Bjornberg et al. 2003; Sanzo et al. 2001; Svensson et al. 1992). Exposures to inorganic mercury (IHg) are from multiple sources including: dental amalgams (Halbach et al. 2000; Kingman et al. 1998), "folk" or patent medicines (Riley et al. 2001), cosmetic preparations (Al-Saleh and Shinwari 1997; Balluz et al. 1997; Gabrio et al. 2003; Weldon et al. 2000), residential and/or school accidental or deliberate spills, occupational exposures (Mason et al. 2001), and trace quantities in foods of plant origin (Jedrzejczak 2002). High IHg exposures can result in elevated BTHg, whereas blood IHg (BIHg) is usually low. Until IHg exposure is substantially elevated, IHg is excreted in the urine (Mason et al. 2001). By contrast, MHg accumulates in the erythrocyte across a wide range of exposures (Kershaw et al. 1980; Sherlock et al. 1984; Skerfving et al. 1974; Svensson et al. 1992).

Among people who consume fish and do not have a high exposure to IHg, increased BTHg reflects exposure to OHg. For fish consumers, as BTHg rises a greater fraction of BTHg is blood organic mercury (BOHg). Fish-associated exposures producing BTHg in the range of approximately 30 µg/L to > 140 µg/L have been reported in diverse geographic locations in the United States (Burge and Evans 1994; Hightower and Moore 2003; Knobeloch et al. 1995; Smith JG, personal communication). Groups of people with BTHg in this range include recreational anglers, subsistence fishers, members of some Native American Tribes, and others consuming a substantial portion of dietary protein from fish in pursuit of health benefits. The latter group has been reported by Hightower and Moore (2003), who identified seriously elevated BTHg (up to ~ 90 µg/L) in a case series of affluent patients identified through a private medical practice in San Francisco.

Background on Dietary Mercury

Estimated population exposures to dietary Hg can be determined through chemical analyses of total Hg in foods (Gunderson 1995; Larsen et al. 2002; Nakagawa et al. 1997; Sanzo et al. 2001; Urieta et al. 1996; Ysert et al. 2000). Within the diet, fish and shellfish contain the highest Hg concentrations (Larsen et al. 2002; Urieta et al. 1996; Ysert et al. 2000), although trace amounts of total Hg may be detected in other dietary components [e.g., eggs, organ meats such as kidney (Larsen et al. 2002), or offal (Ysert et al. 2000)]. Diets are usually analyzed for total Hg without chemical speciation to differentiate between organic mercury, specifically methyl mercury, and IHg. Based on total diet data for the United States, in which only total Hg is measured; Hg is identified routinely only in the fish and shellfish components of diet. MacIntosh et al. (1996) indicated that dietary Hg exposures at the upper end of the estimated distribution for approximately 120,000 adults were dominated by the consumption of fish products (87%), principally canned tuna (65%), in the Nurses' Health Study and Health Professional Follow-Up Study. The OHg in fish and shellfish has been repeatedly speciated and is MHg (Bloom 1992; Falter and Scholer 1994; Haxton et al. 1979; Kannan et al. 1998). Subsequently, in this report dietary Hg will be referred to as MHg.

Variation in methyl mercury concentrations in fish. MHg concentrations in fish and shellfish species range from < 0.1 ppm for shellfish, such as oysters and mussels, to multiple parts per million reported in high-end predatory fish including ocean fish [such as tuna (Storelli and Marcotrigiano 2001; Storelli et al. 2002), marlin (Schultz et al. 1976), swordfish (Storelli and Marcotrigiano 2000), and shark (Penedo de Pinho et al. 2002)] and freshwater fish [e.g., walleye and northern pike (Gilmour et al. 2000; Jewett et al. 2003)]. Consequently, Hg intake depends on the species of fish consumed as well as the quantity of fish eaten.

Hg present in fish is approximately 85% MHg and higher for fish muscle (e.g., Storelli et al. 2002). In nonmuscle animal tissues (e.g., organs such as kidney or liver), the fraction of

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total Hg that is MHg is substantially less than 80–90%, but for the general U.S. population, consumption of these nonmuscle fish tissues is infrequent.

Association between dietary intake of mercury and blood mercury concentrations. In the initial report of 1999–2000 National Health and Nutrition Examination Survey (NHANES) BTHg data (Schober et al. 2003), fish consumption was defined by a simple "yes/no" response on whether the examinee reported eating fish and/or shellfish within the past 30 days. The purpose of the current report is to describe the association between blood total and calculated organic mercury intake of MHg from fish and shellfish as reported by participants in 1999–2000 NHANES. A second purpose of this article is to estimate the influence of long-term (i.e., 30-day) MHg intake on BMHg.

Methods

Analyses in this article are based on data obtained from participants in 1999–2000 NHANES conducted by the National Center for Health Statistics (NCHS); these data are publicly available on the NCHS website (NCHS 2003). The survey sample was selected through a complex multistage design based on primary sampling units (counties), household segments within the counties, and finally, sample persons from selected households. Blacks (different locations on the NCHS website use both the terms "African American" and "black" to describe the same 370 participants whose data are reported in this article), Mexican Americans, persons in the age group 12–19 years, and persons ≥ 60 years of age were oversampled to obtain reliable estimates of health and nutrition measures for these population subgroups. Low-income whites and pregnant women were also oversampled. There were 280 women with positive pregnancy tests included among the 1999–2000 participants. Twenty-six individual geographic locations were included in the 1999–2000 survey. The survey data were statistically weighted to maintain the representativeness of the sample for the U.S. population as well as the major subpopulations.

Whole-blood samples were analyzed for both BTHg and BIHg for participants in the age groups 1–5 and 16–49 years. Mercury analyses were conducted by cold-vapor atomic absorption spectrophotometry with detection limits of 0.14 µg/L for BTHg and 0.4 µg/L for BIHg. BOHg levels were not analytically quantified in 1999–2000 NHANES. Methodologies and quality control procedures have been described by the NCHS (2003).

Fish and shellfish consumption. Participants completed a 24-hr dietary recall interview as well as an interview in which they were asked about the consumption of fish and/or shellfish during the past 30 days.

Mercury concentrations in fish and shellfish. Mercury concentrations in marine, estuarine, and freshwater fish were obtained from databases maintained by the National Marine Fisheries Service (NMFS) for marine and estuarine fish and shellfish [National Marine Fisheries Service 1978, reported by Hall et al. (1978)] and freshwater fish (Bahnick et al. 1994). Analyses of Hg in fish were based on flameless (cold-vapor) atomic absorption spectrophotometry after chemical digestion of the fish sample (Hall et al. 1978). The mean value for Hg concentrations in the fish or shellfish species was used in calculation of dietary Hg intake. The individual data for 35 species of fish and shellfish have been presented in detail elsewhere (Mercury Study Report to Congress 1997) and are summarized in Table 1.

Calculation of mercury concentrations in fish dishes. The 1999–2000 NHANES participants' Hg intakes from fish were estimated by combining data on Hg concentrations in fish species with the reported quantities and types of fish species consumed. The U.S. Department of Agriculture (USDA) has developed a recipe file identifying the primary components that make up the food or dish reported eaten by a survey respondent (Mercury Study Report to Congress 1997). The total weight of a fish-containing food is typically not 100% fish. The food code specifies a preparation method and gives additional ingredients used in preparation of the dish. For example, in the recipe file, "Fish, floured or breaded, fried" contains 84% fish by weight. Fish dishes contained a wide variety of fish species in varied amounts: from approximately 5% for a frozen "shrimp chow mein dinner with egg roll and peppers" to 100% for fish consumed raw, such as raw tuna.

Using these recipe files available from the USDA (Mercury Study Report to Congress

Table 1. Hg concentrations in fish species (µg Hg/g fresh weight), reported to be consumed by women in NHANES, 1999–2000.

Fish and shellfish species	Average Hg concentration (µg/g)	Source
Sharks	1.327	Mercury study[a] 1997
Swordfish	0.95	Mercury study[a] 1997
Porgy	0.522	NMFS data (Hall et al. 1978)
Walleye	0.52	Bahnick et al. 1994; U.S. EPA 1992
Bass, freshwater	0.38	Bahnick et al. 1994; U.S. EPA 1992
Northern pike	0.31	Bahnick et al. 1994; U.S. EPA 1992
Halibut	0.25	Mercury study[a] 1997
Snapper	0.25	Mercury study[a] 1997
Lobster	0.232	Mercury study[a] 1997
Tuna (albacore and skipjack)	0.206	Mercury study[a] 1997
Skate	0.176	NMFS data (Hall et al. 1978)
Catfish, channel and flathead	0.16	Bahnick et al. 1994; U.S. EPA 1992
Pollock	0.150	Mercury study[a] 1997
Trout	0.149	Mercury study[a] 1997
Brown trout	0.14	Bahnick et al. 1994; U.S. EPA 1992
Sea bass	0.135	NMFS data (Hall et al. 1978)
Croaker	0.125	Mercury study[a] 1997
Cod	0.121	Mercury study[a] 1997
Crab	0.117	Mercury study[a] 1997
Perch, ocean	0.116	Mercury study[a] 1997
Carp	0.11	Bahnick et al. 1994; U.S. EPA 1992
Perch, white and yellow	0.11	Mercury study[a] 1997
Pompano	0.104	Mercury study[a] 1997
Sardines	0.1	NMFS data (Hall et al. 1978)
Smelt	0.1	Mercury study[a] 1997
Carp, common	0.093	Mercury study[a] 1997
Flounders	0.092	Mercury study[a] 1997
Haddock	0.089	Mercury study[a] 1997
Catfish (channel, large mouth, rock, striped, white)	0.088	Mercury study[a] 1997
Mackerel (not king mackerel)	0.081	Mercury study[a] 1997
Crab, king	0.07	Mercury study[a] 1997
Shrimp	0.047	Mercury study[a] 1997
Scallops	0.042	Mercury study[a] 1997
Whiting (silver hake)	0.041	NMFS data (Hall et al. 1978)
Salmon	0.035	Mercury study[a] 1997
Octopus	0.029	Mercury study[a] 1997
Squid	0.026	Mercury study[a] 1997
Clams	0.023	Mercury study[a] 1997
Oysters	0.023	Mercury study[a] 1997
Herring	0.013	Mercury study[a] 1997
Mullet	0.009	Mercury study[a] 1997

U.S. EPA, U.S. Environmental Protection Agency.
[a]Mercury Study Report to Congress (1997).

1997), the average Hg concentration in the fish species (micrograms per gram) for a particular reported fish-containing dish on a fresh-weight basis (Bahnick et al. 1994; Hall et al. 1978) was used to calculate the quantity of Hg in a gram portion of the food item. Earlier research (Bloom 1992; Falter and Scholer 1994; Morgan et al. 1997; Storelli et al. 2002) indicated that > 90% of Hg present in fish and shellfish is chemically speciated as MHg, which is bound to protein in fish tissue. MHg bound to muscle tissue is not removed during typical cooking processes such as pan frying, baking, boiling, broiling, or deep frying (Chicourel et al. 2001; Morgan et al. 1997; Sherlock et al. 1984). Consequently, the MHg present in the fish tissue in the raw state will remain in the cooked or processed fish. However, moisture is lost when fish is processed or cooked. Mercury concentration data were recalculated to reflect the retention of MHg in the remaining lowered-moisture–content fish dishes. Based on information from the USDA (Mercury Study Report to Congress 1997), the percent moisture lost for baked or broiled fish was 25%; fried fish products lose weight through loss of moisture but increase weight from fat added during frying, for a total weight loss of 12%. The percent moisture in dried, pickled, or smoked fish was identified for individual fish species (e.g., herring, cod, trout) from USDA handbooks of food composition (Mercury Study Report to Congress 1997).

Intake of methyl mercury from fish and shellfish. Projected month-long estimates of fish/shellfish intake and Hg exposure have been developed for individual adult female participants, based on the reported frequency of fish/shellfish consumption data in the preceding 30-day period and the 24-hr recall dietary intake data for the individual as the basis for portion size. The body weight (bw) in kilograms of the individual, measured in the NHANES examination center, was used to calculate Hg exposure on a microgram per kilogram bw basis.

The 24-hr recall data contain a USDA food code and the amount eaten in grams for every food item (identified by a unique 7-digit code) reported eaten by each respondent in the 24 hr immediately preceding the interview. Using the USDA recipe file (Mercury Study Report to Congress 1997) that identifies the primary components of each food or dish reported eaten by a survey respondent, the amount of seafood consumed in each food containing seafood was estimated. Summing these products over all meals reported for the 24-hr recall period gives an estimate of the amount of seafood consumed. These summations can be restricted to particular species or to groups of species such as fish or shellfish.

The 30-day recall data contain estimates of the number of times the respondent has eaten each of 32 types of fish or shellfish in the 30 days immediately preceding the interview. There are no data on the amounts eaten. To estimate the amount of seafood consumed over the course of the 30-day recall period, it is necessary to compute the number of times a seafood type is eaten multiplied by the average amount eaten per meal. The products are summed to determine the amount eaten to get total seafood consumption over the 30-day period. The average amounts of a seafood type eaten in a meal were developed from the NHANES 24-hr recall data by averaging over all respondents and meals the amounts of the seafood type reported by each respondent per meal.

Daily intake of Hg was estimated from the 24-hr recall data and the calculated Hg concentrations in fish. The amount of seafood consumed by a respondent in a dish was calculated as described above. This was multiplied by the Hg concentration calculated for each seafood species in the dish. Aggregations to a respondent's estimated daily intake of Hg or to a group's intake were obtained by adding up the applicable products. To estimate the cumulative amount of Hg ingested over the 30-day recall period, it is necessary to multiply the estimated amount of seafood eaten in 30 days by the Hg concentration in the seafood for each of the 32 seafoods and add the products.

Statistical methods. In the previous sections we describe the procedures used to combine the 1999–2000 NHANES data on seafood consumption and the Bahnick et al. (1994) and NMFS data on Hg concentrations in fish to develop estimates of the amounts of seafood (Hall et al. 1978) consumed and the amount of Hg ingested for each survey respondent. Estimates of the distribution of these amounts, statistically representative of the U.S. population and selected subpopulations, were calculated by applying the statistical weights supplied in the NHANES data sets to the consumption and ingestion data. U.S. population estimates were then calculated using WESVAR, a statistical package designed for use with weighted data from complex surveys such as NHANES [see Westat (2003) for description of WesVar specifications, including the statistical procedures used].

All statistical estimates presented in this paper are weighted estimates. They were calculated using the sampling weights developed by NCHS and included in the data on its website (NCHS 2003). Specifically, following NCHS guidance, the 2-year mobile examination center weights were used for all analyses reported in this paper.

To explore the statistical relationships between the estimated amounts of seafood eaten and the concentrations of Hg in the blood, several regression models were developed and analyzed. In all of the models, the dependent variable was a function of the BHg concentration. Four dependent variables were employed: BTHg, the logarithm of the BTHg, BMHg, and the logarithm of BMHg. Three sets of independent variables were incorporated in the models: estimated 30-day fish and shellfish consumption; race/ethnicity; and age. Total fish and shellfish consumption was analyzed in four of the models. In the other four models, fish and shellfish consumption was split into four variables; *a*) tuna consumption, *b*) consumption of other fish species, *c*) shrimp consumption, and *d*) consumption of other shellfish species. Logarithms of fish and shellfish consumption were used in the models with the logarithms of the dependent variables. The same race/ethnicity and age variables were used in all eight models. The five race/ethnicity categories require four indicator variables in the regression models, with the fifth category, non-Hispanic white, being the reference category. Thus, the regression coefficients for the other race/ethnic groups are relative to the non-Hispanic white category.

In developing the regression models and following standard statistical practice, the data were reviewed for outliers and other data points that could disproportionately affect the results. This review resulted in the elimination of five data points: three had fish/shellfish consumption between 5,303 and 7,848 g and BTHg < 5 µg/L, and two had BTHg of 30.3 and 38.9 µg/L but seafood consumption < 500 g. These were the extreme cases for both BTHg and fish/shellfish consumption in the data set. In no other cases was fish/shellfish consumption > 4,715 g or BTHg > 22 µg/L. The available data do not allow the determination of the causes of these extreme cases. They may be erroneous data or evidence of different, unidentified contributory factors. It was decided to remove them from the regression analyses.

Presentation of both blood total mercury and calculated blood organic mercury: methodologies. The NHANES data files contain data on BTHg and BIHg, not BOHg. BOHg/methyl mercury (BMHg) was generally calculated as BTHg minus BIHg. This calculation is complicated by the fact that the limit of detection (LOD) for BIHg is larger than the LOD for BTHg (0.4 ppb and 0.14 ppb, respectively). Therefore, negative values for calculated BOHg may result when both are near or below their respective LODs. Approximately one-fourth of the sample (591 participants of 2,386) have negative values (BTHg minus speciated BIHg). To address this difficulty, we calculated BOHg as follows: BOHg = BTHg minus speciated BIHg if the difference is ≥ 0. If the difference is < 0, set BOHg = 0.2 µg/L.

The proposed value for BOHg when the difference is negative (0.2 μg/L) is based on the observation that in all but 6 of the 591 cases for which the difference is negative, speciated BIHg ≤ 0.4 μg/L and BTHg ≤ 0.3 μg/L (at or slightly above its LOD). If we assume that BOHg has the same LOD as BIHg, then we can set BOHg equal to one-half the BIHg LOD, or 0.2 μg/L.

Results

Blood total mercury. BTHg contains both BOHg, predominantly BMHg, and BIHg. Previous publication of BTHg data from 1999–2000 NHANES (Schober et al. 2003) has described BTHg. Schober et al. (2003) used SUDAAN software, which is based on jackknife estimation, whereas the present analyses used WesVar, which is based on balanced repeated replication estimation. The distribution of total BTHg using WesVar is presented in Table 2. These data confirm the distribution of BTHg concentrations presented by Schober et al. (2003). In addition, the current analysis presents separate values for persons in the category of Other among racial/ethnic groups. Participants who designated themselves as Other include Native American Tribal people, individuals of Pacific Island origin, persons of Asian origin, and persons of mixed race who did not designate another category. Women in the Other race category have the highest prevalence of BTHg [the BTHg associated with U.S. Environmental Protection Agency's (EPA) reference dose (RfD) for methyl mercury] at 21.7%. Mexican-American women have the lowest prevalence, at 2.0% (Table 3).

Table 2 indicates that BTHg concentrations are higher among 30- to 49-year-old women than among younger women. This difference is observed across the entire distribution of BTHg over the age range of 16–49 years. At the 90th percentile and the 95th percentile, Mexican Americans have the lowest BTHg levels, Other racial/ethnic groups the highest, and exposures are similar for other Hispanics, non-Hispanic blacks, and non-Hispanic whites.

Treatment of outliers. As previously discussed, the NHANES data on approximately 1,700 women contain a few outliers: the previously described two cases with very large BTHg values and low fish/shellfish consumption, and the three cases with high fish/shellfish consumption and low total BHg. In addition, one woman had BMHg equaling 27.7 μg/L and BIHg equaling 11.2 μg/L, and another woman had BMHg equaling 9.3 μg/L and BIHg equaling 11.0 μg/L. These two unusual cases do not alter the results and conclusions derived from the approximately 1,700 other participants.

Blood organic mercury. Previous research has established that the BOHg compound is MHg (Bjornberg et al. 2003; Sanzo et al. 2001; Svensson et al. 1992). Table 4 presents the distribution of organic (or MHg) among female 1999–2000 NHANES participants 16–49 years of age. Because the detection limit for BIHg was higher than the detection limit for BTHg, the lower percentiles were below the LOD for all age and ethnic groups. The distribution of BMHg parallels the distribution of BTHg for 1,707 women. Table 4 also relates BMHg to the reported 30-day frequency of fish and/or shellfish consumption. BMHg increases with increasing frequency of fish and/or shellfish consumption. Women who eat fish and/or shellfish at least twice a week have average BMHg concentrations seven times greater than women who reported no fish/shellfish consumption in the previous 30 days.

Fish and shellfish consumption. Reported consumption of fish and shellfish (grams per day based on 24-hr recall) was not identified until the 86th percentile of the distribution for any of the race/ethnic categories (Table 5). Fish and shellfish consumption are highest among non-Hispanic black women. Consumption of fish and shellfish is higher among women 30–39 years of age than in any other age group (Table 5). Overall, 14.0% of women reported consumption of fish and/or shellfish in the 24-hr recall.

Methyl mercury consumption. Based on variability in quantity and species of fish and shellfish consumed and using an average mercury concentration for a specific fish/shellfish species, consumption of MHg was estimated and is reported in Tables 6 and 7 for the 24-hr recall data both as total Hg intake and on a microgram per kilogram bw basis. Table 7 shows that all race/ethnic categories and all age categories were ≥ 0.1 μg/kg bw mercury at the 95th percentile.

Table 3. Percentage of women 16–49 years of age with BTHg concentrations (μg/L) above selected thresholds, by age and race/ethnic group, 1999–2000 NHANES.[a,b]

	Sample persons	Percentage ≥ 15.0 μg/L	Percentage ≥ 5.8 μg/L	Percentage ≥ 5.0 μg/L	Percentage ≥ 3.5 μg/L
Total	1,709	0.6	7.8	9.7	15.7
Race/ethnicity					
Mexican American	579	0.3	2.0	2.7	6.1
Other Hispanic	124	2.0	5.8	5.9	16.4
Non-Hispanic white	578	0.1	7.8	10.0	15.3
Non-Hispanic black	364	1.3	7.0	9.5	16.6
Other	64	3.5	21.7	24.8	31.5
Age (years)					
16–19	513	0.5	2.4	2.8	4.9
20–29	437	1.2	7.6	9.6	12.8
30–39	405	0.6	8.8	10.5	15.8
40–49	354	0.2	8.8	11.4	22.1

[a]Data are from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Table 2. BTHg concentrations (μg/L) for women 16–49 years of age, by age and race/ethnic group, 1999–2000 NHANES.[a,b]

	Sample persons	Geometric mean	95% CI	Percentiles 5th	10th	25th	50th	75th	90th	95th
Total	1,709	1.02	0.85–1.20	ND	0.17	0.42	0.94	2.07	4.84	7.13
Race/ethnicity										
Mexican American	579	0.82	0.68–0.96	0.11	0.20	0.38	0.84	1.44	2.50	3.91
Other Hispanic	124	1.16	0.77–1.55	ND	0.15	0.47	1.21	2.52	4.38	8.79
Non-Hispanic white	578	0.96	0.76–1.16	ND	0.16	0.38	0.86	1.83	4.89	7.08
Non-Hispanic black	364	1.35	1.08–1.61	0.16	0.33	0.64	1.34	2.59	4.74	6.55
Other	64	1.32	0.35–2.28	ND	0.25	0.39	1.20	4.86	8.24	10.04
Age (years)										
16–19	513	0.63	0.49–0.76	ND	ND	0.24	0.58	1.33	2.47	3.28
20–29	437	0.87	0.68–1.06	ND	ND	0.34	0.79	1.67	4.79	6.43
30–39	405	1.09	0.84–1.35	0.13	0.19	0.47	0.97	1.97	5.07	8.95
40–49	354	1.32	1.04–1.60	0.18	0.30	0.61	1.24	2.97	5.31	7.13

ND, concentration < LOD (0.14 μg/L).
[a]Data from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Association between dietary mercury intake and blood total mercury and blood organic mercury. The adjusted multiple correlation coefficient (R) for the association between quantity of fish and shellfish eaten per kilogram bw and BHg was 0.54 for BTHg and 0.55 for BOHg (i.e., BMHg) (Table 8). Log transformation of the BTHg consumed variable yielded a lower R for both BTHg (R = 0.47) and for BMHg (R = 0.48) compared with the untransformed variable.

Separating Hg intake of tuna (0.206 ppm) and shrimp (0.047 ppm), the two most commonly consumed fish/shellfish products, from other species of fish/shellfish species increased the strength of the association between BTHg, BOHg, and fish consumption slightly. All fish/shellfish consumption is a significant predictor of BTHg and BOHg. Each gram of fish/shellfish consumed per kilogram bw was associated with an increase of 0.2–0.5 µg/L MHg in blood for each gram of fish/shellfish consumed per kilogram bw. If fish/shellfish species are subdivided, tuna consumption and other fish consumption are both very highly significant predictors (i.e., $p < 0.05$), each predicting a BHg increase of 0.2–0.5 µg/L for each gram of fish/shellfish consumed per kilogram bw. In two of the models, log (other shellfish) has a negative coefficient with a very large p-value. That is, the effect on BTHg and BOHg is essentially zero. Age is also significant in all but one of the models, with a consistent coefficient, approximately 0.02. Finally, the coefficients for the race/ethnicity variables estimate the differences between the respective race/ethnic groups and the non-Hispanic white group. In most of the models, non-Hispanic blacks and other Hispanics (not Mexican Americans) are significantly different from non-Hispanic whites in BTHg and BOHg when recent (30-day) fish/shellfish consumption and age are held constant.

Discussion

As BTHg concentrations increase, the fraction of BTHg that is BMHg increases (Figure 1). The top 10% of women in the Other race/ethnic category had BMHg concentrations approximately twice that of women in the other racial/ethnic categories (Table 4). More than 20% of women in the Other category had BTHg values > 5.8 µg/L (Table 3). The top 10% of women in the 20- to 49-year-old categories had BMHg values more than twice that of women in the 16- to 19-year-old category (Table 4).

Two of the women who were outliers had BTHg > 5.8 µg/L and also had BMHg > 5.8 µg/L. Although the organic fraction of Hg in blood was not speciated for blood samples from the 1999–2000 NHANES participants, exposures of adult women to organic mercurials other than MHg in fish and shellfish have not been documented except for unusual situations after occupational exposure (Nierenberg et al. 1998). Except for exposures of young children to an organic mercurial (Thimerosal) used as a preservative in vaccines (CDC 2000) and the potential for a rare occupational exposure to organic mercurials, BOHg is predominantly MHg from fish and shellfish consumption.

Table 5. Total fish/shellfish consumed per day (g) by women 16–49 years of age, by age and race/ethnic group, 24-hr recall data from NHANES, 1999–2000.[a,b]

	Sample persons	Geometric mean	95% CI	Percentage reporting no consumption	Percentiles 75th	90th	95th
Total	1,735	1.8	1.51–2.04	86.0	0.0	42.8	86.9
Race/ethnicity							
Mexican American	587	1.6	1.37–1.77	88.8	0.0	12.0	87.7
Other Hispanic	127	1.9	1.25–2.45	85.2	0.0	56.5	108.7
Non-Hispanic white	582	1.7	1.34–2.02	86.6	0.0	32.6	85.3
Non-Hispanic black	372	2.4	1.73–3.1	79.2	0.0	73.8	142.1
Other	67	1.8	0.99–2.66	85.2	0.0	33.5	75.5
Age (years)							
16–19	523	1.5	1.19–1.81	89.3	0.0	2.1	56.5
20–29	448	1.8	1.44–2.1	85.8	0.0	49.5	85.1
30–39	402	2.0	1.51–2.48	82.7	0.0	54.0	95.0
40–49	362	1.7	1.34–1.96	87.5	0.0	28.0	85.8

[a]Data are from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Table 4. Blood organic (MHg) concentrations (µg/L) for women 16–49 years of age, by age and race/ethnic group, 1999–2000 NHANES.[a,b]

	Sample persons	Geometric mean	95% CI	Percentiles 5th	10th	25th	50th	75th	90th	95th
Total	1,707	0.80	0.66–0.34	ND	ND	ND	0.60	1.70	4.44	6.73
Race/ethnicity										
Mexican American	578	0.57	0.48–0.67	ND	ND	ND	0.44	1.03	2.09	3.42
Other Hispanic	123	0.97	0.65–1.29	ND	ND	ND	0.90	2.14	4.09	8.44
Non-Hispanic white	578	0.75	0.59–0.90	ND	ND	ND	0.48	1.44	4.40	6.68
Non-Hispanic black	364	1.01	0.78–1.24	ND	ND	ND	1.01	2.29	4.34	6.19
Other	64	1.06	0.18–1.34	ND	ND	ND	0.80	4.59	7.94	9.64
Age (years)										
16–19	513	0.49	0.4–0.58	ND	ND	ND	ND	1.00	2.03	2.88
20–29	436	0.70	0.54–0.87	ND	ND	ND	0.44	1.33	4.50	6.10
30–39	405	0.83	0.61–1.04	ND	ND	ND	0.61	1.60	4.65	8.62
40–49	353	1.02	0.79–1.24	ND	ND	ND	0.90	2.56	4.93	6.73
Fish and/or shellfish consumption frequency										
0 times in 30 days (never)	480	0.39	0.34–0.44	ND	ND	ND	ND	0.44	1.1	1.6
1–4 times (< once a week)	780	0.70	0.59–0.82	ND	ND	ND	0.60	1.29	2.9	4.7
5–8 times (≥ 1, < 2 times per week)	230	1.33	1.05–1.60	ND	ND	0.43	1.29	3.29	6.1	9.9
≥ 9 times (≥ 2 times per week)	153	2.46	1.82–3.11	ND	0.44	1.15	2.75	5.20	11.1	12.1
Fish consumption (no shellfish consumed) frequency										
0 times in 30 days (never)	729	0.43	0.37–0.49	ND	ND	ND	ND	0.60	1.4	2.1
1–4 times (< once a week)	733	0.93	0.75–1.11	ND	ND	ND	0.82	1.80	4.4	6.4
5–8 times (≥ 1, < 2 times per week)	118	2.04	1.44–2.63	ND	ND	0.83	2.56	4.54	8.8	11.6
≥ 9 times (≥ 2 times per week)	63	2.70	1.51–3.89	0.39	0.71	1.12	3.02	6.68	12.0	13.4

ND, concentration < LOD (0.4 µg/L).
[a]Data are from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Fish and shellfish as sources of methyl mercury. Analyses of total diet by the U.S. Food and Drug Administration (U.S. FDA) indicate that fish and shellfish are almost exclusively the source of Hg (specifically MHg) in the U.S. diet (Gunderson 1995; U.S. FDA 2000). The Total Diet Study data from the U.S. FDA (2000) report an occasional (i.e., about 4% of samples) trace Hg value (i.e., greater than the detection limit but less than the quantification limit) in beef liver, spinach, oatmeal, and chicken. Except for one of 26 samples of chicken, which contained 1 µg Hg/g chicken, the other nonfish foods had nondetectable levels. Similar findings were seen in Spain (Sanzo et al. 2001), Japan (Nakagawa et al. 1997), United Kingdom (Ysert et al. 2000), Germany (Wilhelm et al. 1995), and Denmark (Larsen et al. 2002).

Surveys on a regional level and national level indicate BHg is associated with the overall level of fish consumed (Sanzo et al. 2001; Urieta et al. 1996). Urieta et al. (1996) determined that adults (25–60 years of age) ingested an average of 18 µg Hg/day, with 80–90% coming from fish and shellfish. Sanzo et al. (2001) confirmed an increase in erythrocyte Hg as fish consumption increased and reported that 30% of the variance in erythrocyte Hg was explained by recent consumption of fish. Ikarashi et al. (1996) reported most Hg in the diet is found in the fish and shellfish component. At higher intakes of Hg from diet, the contribution from fish/shellfish is over 95% of dietary intake (Haxton et al. 1979).

National data on the association between dietary fish intake and blood mercury. When Hg intake is consistent and prolonged, there is a well-defined association between Hg in blood and Hg in diet. The *R* for 1999–2000 NHANES indicated the association between BMHg and estimated MHg intake from fish/shellfish was approximately 0.5. There are several factors that influence the magnitude of this association. The first and most commonly assumed limitation is a person's ability to recall what they have eaten. In the United States, approximately 9% of women consume fish at least once a week. Because fish and shellfish are generally easily identifiable components of diet,

Table 6. Estimated amount of Hg ingested in 1 day (µg) through fish/seafood consumption for women 16–49 years of age, by age and race/ethnic group, 1999–2000 NHANES.[a,b]

	Sample persons	Geometric mean	95% CI	Percentiles 75th	90th	95th
Total	1,735	1.22	1.15–1.29	0.0	2.6	8.5
Race/ethnicity						
Mexican American	587	1.2	1.09–1.25	0.0	0.3	5.9
Other Hispanic	127	1.3	1.09–1.56	0.0	2.3	15.5
Non Hispanic white	582	1.2	1.09–1.26	0.0	1.9	7.4
Non-Hispanic black	372	1.4	1.13–1.64	0.0	5.9	16.4
Other	67	1.3	0.9–1.67	0.0	1.1	7.7
Age (years)						
16–19	523	1.2	1.05–1.26	0.0	0.6	4.5
20–29	448	1.3	1.15–1.41	0.0	2.7	13.0
30–39	402	1.2	1.11–1.35	0.0	3.3	9.9
40–49	362	1.2	1.07–1.29	0.0	1.4	8.3

[a]Data are from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Table 7. Estimated amount of Hg ingested in 1 day (µg/kg bw) through fish/shellfish consumption by women 16–49 years of age, by age and race/ethnic group, 1999–2000 NHANES.[a,b]

	Sample persons	Geometric mean	95% CI	Percentiles 75th	90th	95th
Total	1,727	0.02	0.02–0.03	0.00	0.04	0.13
Race/ethnicity						
Mexican American	584	0.02	0.01–0.03	0.00	0.01	0.09
Other Hispanic	127	0.03	0.01–0.04	0.00	0.04	0.22
Non-Hispanic white	579	0.02	0.01–0.02	0.00	0.03	0.11
Non-Hispanic black	370	0.05	0.01–0.09	0.00	0.06	0.28
Other	67	0.05	0.00–0.11	0.00	0.02	0.10
Age (years)						
16–19	522	0.02	0.01–0.02	0.00	0.01	0.09
20–29	447	0.03	0.02–0.04	0.00	0.04	0.19
30–39	399	0.02	0.01–0.03	0.00	0.05	0.12
40–49	359	0.02	0.01–0.05	0.00	0.02	0.12

[a]Data are from NCHS (2003). [b]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

Table 8. Summaries of regressions of BHg on fish/shellfish consumption, race/ethnic group,[a] and age for women 16–49 years of age, 1999–2000 NHANES.[b,c]

					Independent variables (regression coefficients (*p* values))								
					Fish/shellfish consumed per kilogram bw					Race/ethnic group			
Dependent variable	Sample size	Model fit statistics *R*	R^2	Independent variable measurement scale	Total fish and shellfish	Tuna	Other fish	Shrimp	Other shellfish	Non-Hispanic black	Mexican American	Other Hispanic	Other	Age
BTHg	1,636	0.54	29%	Original	0.258	—	—	—	—	0.343	−0.002	0.545	0.290	0.022
					(< 0.0001)	—	—	—	—	(0.011)	(0.985)	(0.006)	(0.278)	(< 0.0001)
Log BTHg	1,093	0.47	22%	Logarithm	0.452	—	—	—	—	0.227	0.081	0.456	0.302	0.017
					(< 0.0001)	—	—	—	—	(0.003)	(0.250)	(< 0.0001)	(0.047)	(< 0.0001)
BOHg	1,634	0.55	30%	Original	0.249	—	—	—	—	0.307	−0.094	0.550	0.274	0.020
					(< 0.0001)	—	—	—	—	(0.017)	(0.409)	(0.004)	(0.279)	(< 0.0001)
Log BOHg	1,092	0.48	23%	Logarithm	0.508	—	—	—	—	0.250	−0.007	0.557	0.388	0.020
					(< 0.0001)	—	—	—	—	(0.005)	(0.928)	(< 0.0001)	(0.028)	(< 0.0001)
BTHg	1,636	0.54	30%	Original	—	0.240	0.322	0.081	0.224	0.294	0.013	0.562	0.300	0.021
					—	(< 0.0001)	(< 0.0001)	(0.242)	(< 0.0001)	(0.031)	(0.915)	(0.005)	(0.270)	(< 0.0001)
Log BTHg	76	0.64	40%	Logarithm	—	0.273	0.422	0.386	−0.300	−0.349	0.424	0.314	3.617	0.022
					—	(0.018)	(0.003)	(0.028)	(0.820)	(0.184)	(0.235)	(0.335)	(0.084)	(0.057)
BOHg	1,634	0.55	31%	Original	—	0.236	0.307	0.067	0.223	0.266	−0.076	0.569	0.288	0.020
					—	(< 0.0001)	(< 0.0001)	(0.305)	(< 0.0001)	(0.040)	(0.505)	(0.003)	(0.257)	(< 0.0001)
Log BOHg	76	0.63	40%	Logarithm	—	0.360	0.561	0.481	−0.072	−0.306	0.369	0.607	0.302	0.031
					—	(0.018)	(0.003)	(0.039)	(0.677)	(0.377)	(0.158)	(0.162)	(0.057)	(0.046)

—, the respective independent (column) variable is not in the model (row variable).
[a]The race/ethnic group variables are all relative to the non-Hispanic white race/ethnic group. [b]Data are from NCHS (2003). [c]Sample counts vary because of item missing data; displayed counts are the number of participants with available data for this table.

fish and shellfish consumption is more readily recalled than are ingredients of multiple products such as corn oil or wheat flour. In a previous analysis of data from an earlier NHANES, the largest source of error was uncertainty of participants about foods consumed on the recall day (Youland and Engle 1976). Karvetti and Knuts (1985) observed the actual intake of 140 participants and later interviewed them by 24-hr recall. They found that fish was omitted from the dietary recall < 5% of the time and erroneously recalled approximately 7% of the time. The validity of the 24-hr recalls for fish consumption was greater than all other food groups. Supporting results have been reported by others. For example, MacIntosh et al. (1996) determined that based on dietary data from approximately 120,000 U.S. adults, the upper end of the estimated distribution of Hg exposures was dominated by consumption of fish products, principally canned tuna. Within the 1999–2000 NHANES data reported in Table 4, half of the women who consumed fish at least twice a week had BMHg of 3.0 µg/L or greater, whereas < 5% of the women who reported eating no fish reached this threshold.

Another source of uncertainty is the ability to accurately know the species of fish consumed. Many products such as frozen breaded fish are recognized generically by the method of preparation (e.g., fried fish) rather than associated with a specific fish species. Additional uncertainty relates to deliberate misbranding or mislabeling of fish, because some fish species have greater commercial value than other. For example, based on protein banding patterns, less than half the fish labeled as red snapper were red snapper (Anonymous 2001). This problem is also present internationally. For example, in Japan, dolphin has been sold as whale meat (Anonymous Japan Today 2003).

The R statistic for 1999–2000 NHANES participants (~ R = 0.5–0.6) is comparable with associations reported from other studies in which Hg concentrations were chemically analyzed in duplicates of the foods consumed by participants. For example, Sherlock et al. (1982) and Haxton et al. (1979) reported R statistics comparable with those observed in the NHANES data (for Sherlock et al., R = 0.54 with 942 participants and dietary Hg intakes between 68 and 1,145 µg/week; for Haxton et al., R = 0.46 with 174 participants). In this report the 95th percentile Hg consumption was 33 µg/week.

At exposures more comparable with those in the current report, Sanzo et al. (2001) determined fish intakes based on 25 days of diet recall distributed throughout the year (dietary recall approximately every 15 days). The association between Hg intake from fish and erythrocyte total Hg for 120 individuals was statistically significant (R = 0.3, p < 0.001) in erythrocyte Hg as fish intake increased over the range of < 30 g/day to > 115 g/day. Sanzo et al. (2001) reported that fish and shellfish consumption at the 95th percentile was 917 g over 30 days, or 30.6 g of fish and shellfish per day.

Limitations on the strength of the association between blood mercury and mercury intake in the past 30 days. There is a physiological basis that limits the strength of the association between current BMHg and past 30-day fish consumption. Data from metabolic studies evaluating change in BTHg with different amounts of THg in diet indicate that as intake of THg from fish and shellfish increases, BTHg will increase. Constant consumption patterns will result in a more predictable relationship between THg intake and whole blood or erythrocyte MHg. Half-lives of BTHg in human adults are generally given as ~ 70 days; however, individual values as long as 250 days have been reported by Birke et al. (1972). Based on data from 48 patients, al-Shahristani and Shihab (1974) reported that biological half-times of BHg varied between 37 and 189 days, with an average of 72 days. Based on a half-life of ~ 70 days, roughly three-quarters of the BHg is attributable to intake of MHg from fish/shellfish consumed > 30 days previously. Consequently, MHg intake based on an estimate of dietary MHg intake covering only the preceding 30 days will include MHg consumed in an earlier time period and still present in blood because of the length of the half-time for MHg in humans. Half-times for children have not been reported.

An example of the influence of long-term Hg intake can be seen in the results from Sherlock et al. (1984). Groups of adults consumed fish in varying amounts to achieve dietary intakes of THg at 226, 101, 77, and 42 µg/day, and their BTHg and calculated BMHg concentrations were monitored. BMHg rose during the 96-day period of fish consumption to concentrations proportional to dose. Over the dose range of 42–226 µg/day, there was a close to linear relationship between dietary intake of MHg and BMHg concentration. After dosing with MHg stopped, BMHg declined. After 100 days, BMHg concentrations of the subjects remained elevated above baseline values. The lowest dose evaluated by Sherlock et al. was 0.55 µg/kg bw/day. Among the five subjects on this dose (prestudy BMHg concentrations averaged < 3.2 µg/L), BMHg averaged ~ 27 µg/L after 96 days of dosing and declined to ~ 5 µg/L, which was above baseline concentrations.

Whether these relationships can be extrapolated to lower MHg exposures of current concern is not established by data. Sherlock et al. (1982), in reviewing reported data on the relationship between BMHg and MHg intakes, noted that there is a tendency for regression lines with higher slopes to be associated with studies having higher intakes of Hg (Sherlock et al. 1982).

Comparison of distribution of blood mercury with health-based recommendations. In 2000, a National Research Council Committee (NRC 2000) recommended a benchmark dose level of 58 µg/L Hg in cord blood based on developmental effects in young children following *in utero* exposure to MHg and the use of an uncertainty factor (UF) of 10. The benchmark dose is the lower 95% confidence interval (CI) on an estimated dose that doubles the prevalence of children with scores on a test of intellectual development that would fall into the clinically subnormal range (NRC 2000). The U.S. EPA subsequently adopted these recommendations and expanded consideration to multiple studies on the impact of

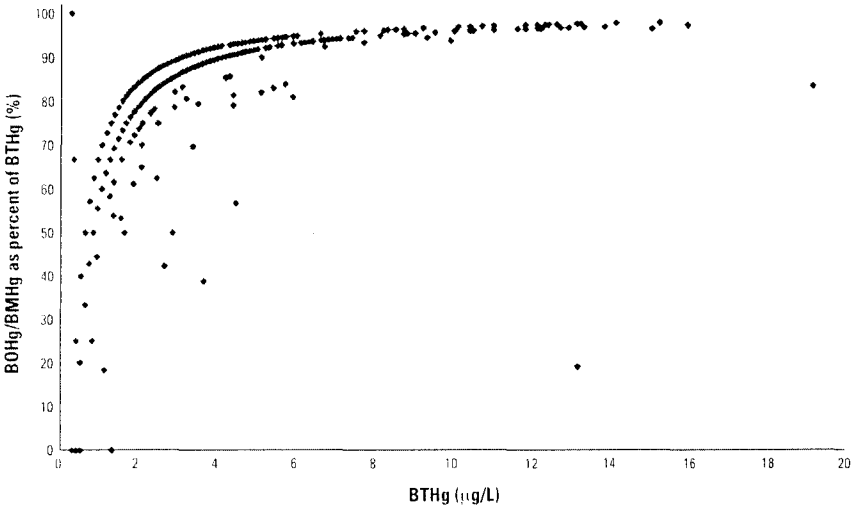

Figure 1. Organic/methyl mercury as percentage of BTHg versus BTHg. Data are from NCHS (2003). This plot is based on 1,733 data points; in many cases, multiple data points have the same values and appear as a single point.

in utero MHg exposure on multiple tests of child development from the Faroese, New Zealand, and Seychelles cohorts (Rice et al. 2003). The NRC committee recommended and the U.S. EPA adopted the use of a UF of 10 to calculate an RfD corresponding to a concentration of 5.8 µg/L Hg in cord blood. At the time of these recommendations, the UF of 10 had been based on the assumption of a 1:1 ratio of cord BHg to maternal BHg. In 1999–2000 NHANES, 7.8% (95% CI, 5.0–10.5) of women 16–49 years of age had BTHg levels at 5.8 µg/L or higher. Based on National Vital Statistics Reports (Ventura et al. 2003), in 2000 the number of births in the U.S. population was 4,058,814. Applying the overall population estimate for adult women of 7.8% having BTHg ≥ 5.8 µg/L (Schober et al. 2003) to the number of newborns in 2000 (Ventura et al. 2003) suggests that > 300,000 newborns per year may have had increased risk of adverse neurodevelopmental effects as a result of *in utero* MHg exposure if a 1:1 ratio of cord BHg to maternal BHg is assumed.

More recent evaluation (Stern and Smith 2003) of the ratio between cord to maternal BHg concentrations indicates that cord blood is, on average, 70% higher in Hg concentration than is maternal blood. Assuming the ratio of 1.7:1.0 and calculating the average BTHg associated with the benchmark dose lower limit and RfD (using the same UF of 10) suggests that a BTHg ≥ 3.5 µg/L may be associated with increased risk to the developing fetal nervous system. The RfD established in 2000 was based on use of a UF of 10 and the assumption that the cord to maternal blood mercury ratio was 1:1 (Rice et al. 2003). An additional possible consideration is that the hemoglobin and hematocrit changes during pregnancy should be considered if comparing BTHg or BMHg of pregnant and nonpregnant women. To that end, comparison of the data for the 280 pregnant women among the 1999–2000 NHANES participants with the 1,941 nonpregnant participants indicates that hemoglobin and hematocrit values at the mean for the pregnant subjects were 10% lower among the 1999–2000 NHANES participants than among the nonpregnant 1999–2000 NHANES adult female participants. (The number of adult female participants having hemoglobin and hematocrit values differs from the number of adult female participants who had BHg analyses.) If the view is taken that the ligands for MHg on hemoglobin are fully saturated at BTHg < 10 µg/L, then the ratio of cord blood to adult nonpregnant women's blood may be more likely to be 1.7:1.1 ($BTHg_{cord}$:$BTHg_{adult\ female}$) rather than 1.7:1.0, and thus associated with BTHg concentrations of 5.8 to ~ 3.8 µg/L rather than 5.8 to ~ 3.5 µg/L. The percentages of women by race/ethnicity and age categories having BTHg ≥ 5.8 µg/L and 3.5 µg/L are provided in Table 3. Overall, 15.7% of women's BTHg concentrations were ≥ 3.5 µg/L, rising to 31.5% for women in the Other race/ethnicity group.

Comparison with health standards of other countries. The German Kommission "Human-Biomonitoring" des Umweltbundesamtes (Human Biomonitoring Commission of the Federal Environmental Office) developed reference values for Hg that are essentially the upper limits for "safe" exposure (Kommission "Human-Biomonitoring" des Umweltbundesamtes 1999). The commission determined that adverse effects in children are judged to occur if during pregnancy the mother's blood contains more than 15 µg/L Hg, roughly equivalent to 4–5 ppm Hg in hair. To provide additional protection, the commission recommended that if a woman of childbearing age has a BTHg level > 5 µg/L or a hair level of approximately 1.5 ppm Hg, a history should be taken to establish whether the woman consumed fish containing organic Hg or used Hg-containing "medicines." If the woman consumed a lot of fish species high in Hg, reduction of fish consumption was advised. If a woman's BTHg level exceeded 15 µg/L, additional medical intervention was recommended by the commission.

Geographic variability in Hg exposure demonstrated by biomarkers of exposure, including hair Hg and BHg level, is well documented. Other nationally based data describing Hg exposure come from the German Environmental Surveys, of which three have been completed, in 1986, 1992, and 1998 (Becker et al. 2002). Overall, BTHg concentrations were lower in the German population compared with the 1999–2000 U.S. female population. Similar trends were observed in both the U.S. and German data, in that as fish consumption increased, BHg also increased. People who reported consuming fish once a week or more had BHg concentrations 2–3 times greater than those of people who reported no fish consumption (Becker et al. 2002).

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Modeling the Transport and Deposition of Atmospheric Mercury to the Great Lakes

(and the Chesapeake Bay)

Dr. Mark Cohen
NOAA Air Resources Laboratory
Silver Spring, Maryland

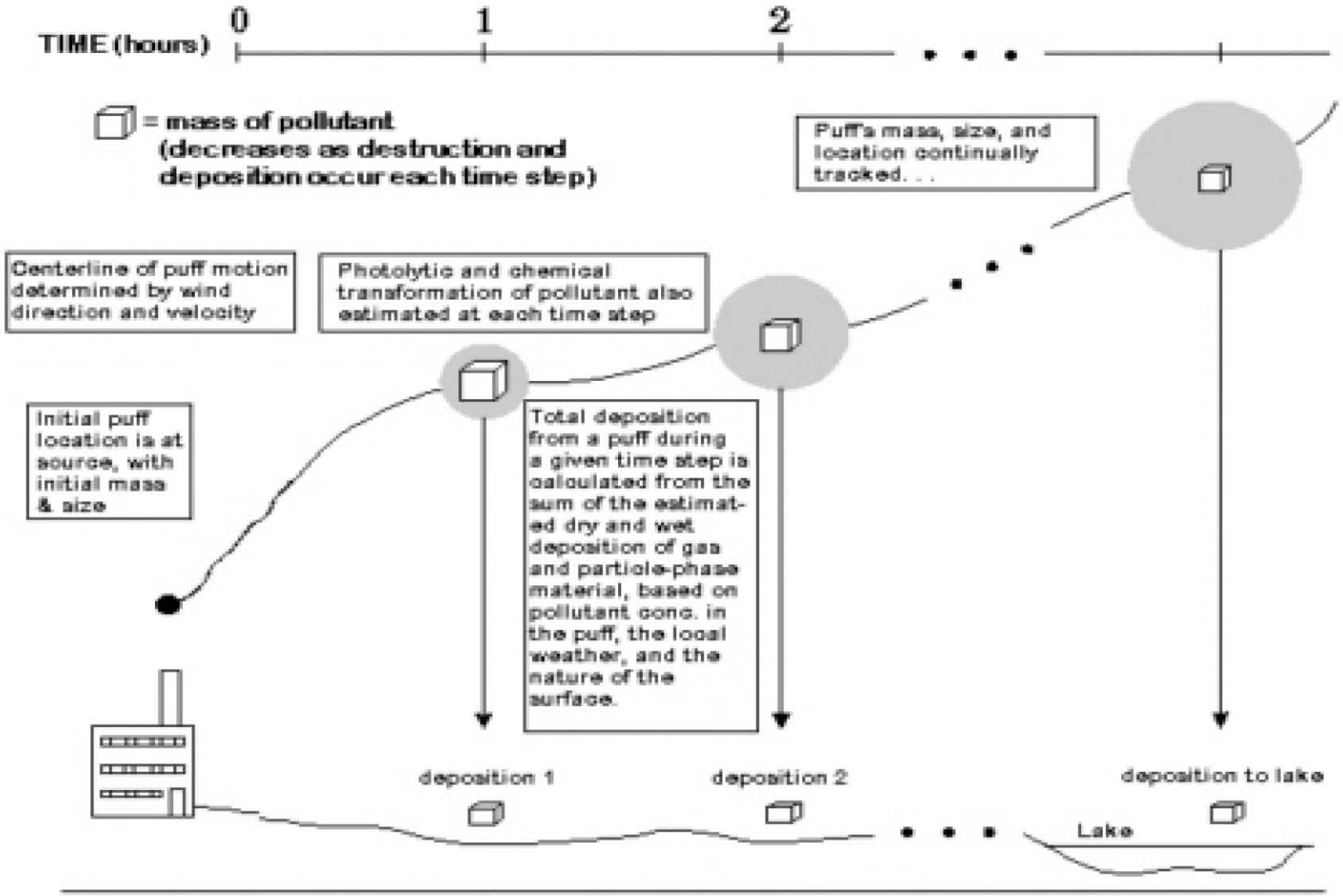
Presentation at the International Conference on Mercury as a Global Pollutant (ICMGP), Llubljana, Slovenia, June 27-July 2, 2004

Goal: **Estimate impacts of *each emissions source* on receptors of interest (e.g., Great Lakes, Chesapeake Bay, etc.) under past, present, and future emissions regimes**

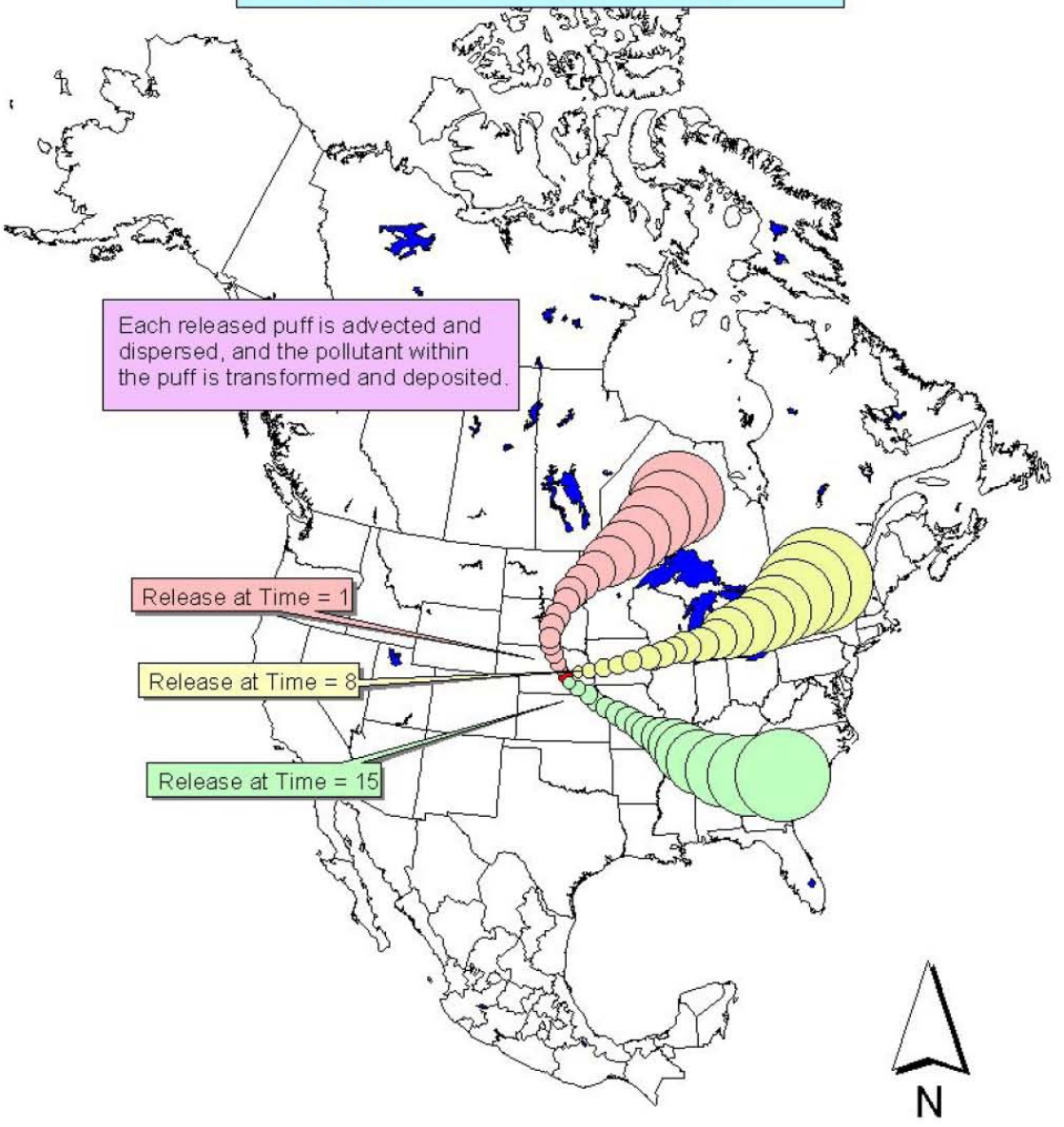
Why? **In order to evaluate reduction strategies, its obviously useful to know the relative importance of different sources, source types, and source regions**

Modeling Methodology

Figure 1. Lagrangian Puff Air Transport and Deposition Model



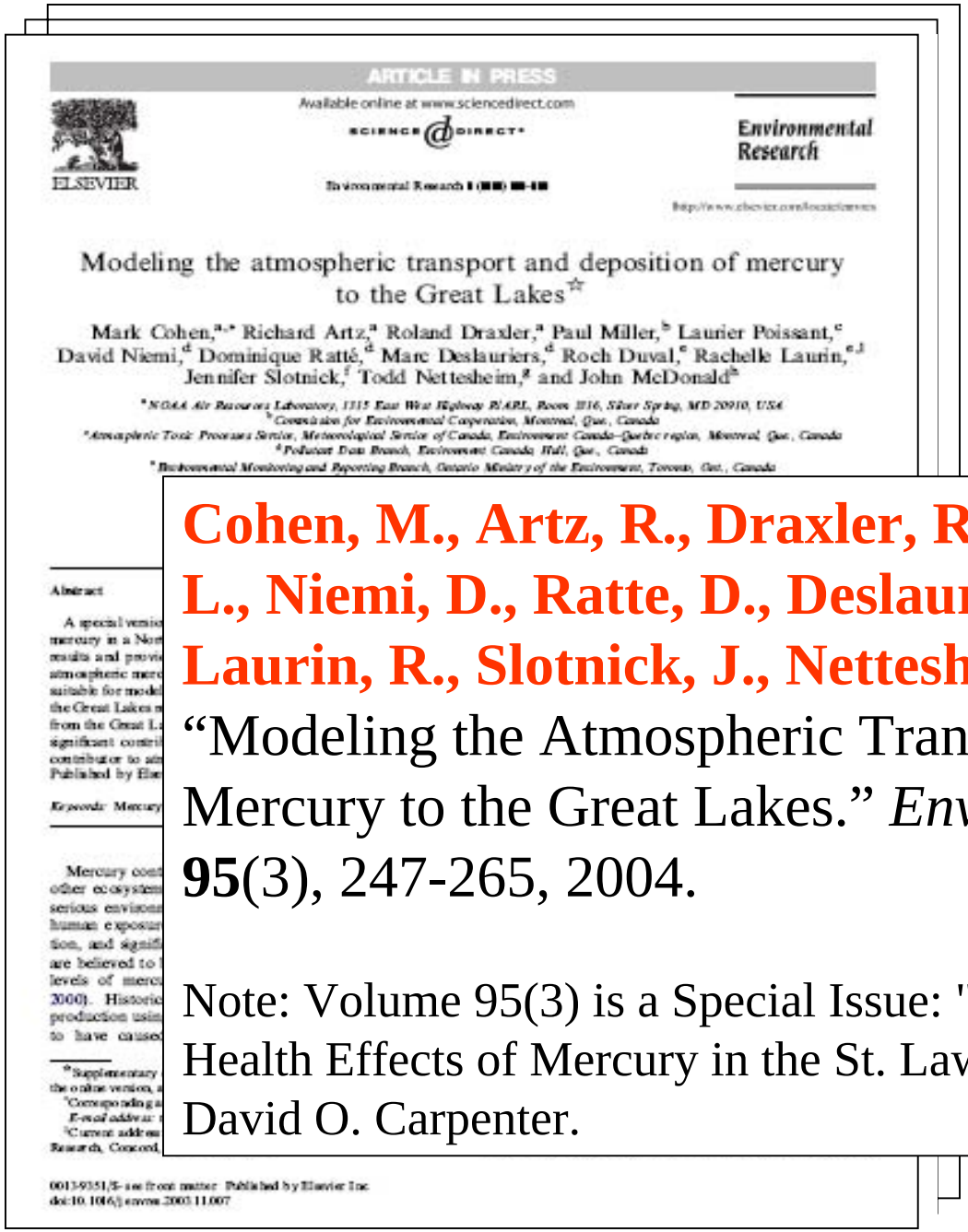
Over the entire modeling period (e.g., one year), puffs are released at periodic intervals (e.g., once every 7 hours).



- **In principle, we need do this for each source in the inventory**

- **But, since there are more than 100,000 sources in the U.S. and Canadian inventory, we need shortcuts…**

- **Shortcuts described in Cohen *et al***
  Environmental Research **95**(3), 247-265, 2004



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Environmental Research

Modeling the atmospheric transport and deposition of mercury to the Great Lakes☆

Mark Cohen,[a,*] Richard Artz,[a] Roland Draxler,[a] Paul Miller,[b] Laurier Poissant,[c] David Niemi,[d] Dominique Ratté,[d] Marc Deslauriers,[d] Roch Duval,[e] Rachelle Laurin,[e,1] Jennifer Slotnick,[f] Todd Nettesheim,[g] and John McDonald[h]

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Abstract

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Keywords: Mercury

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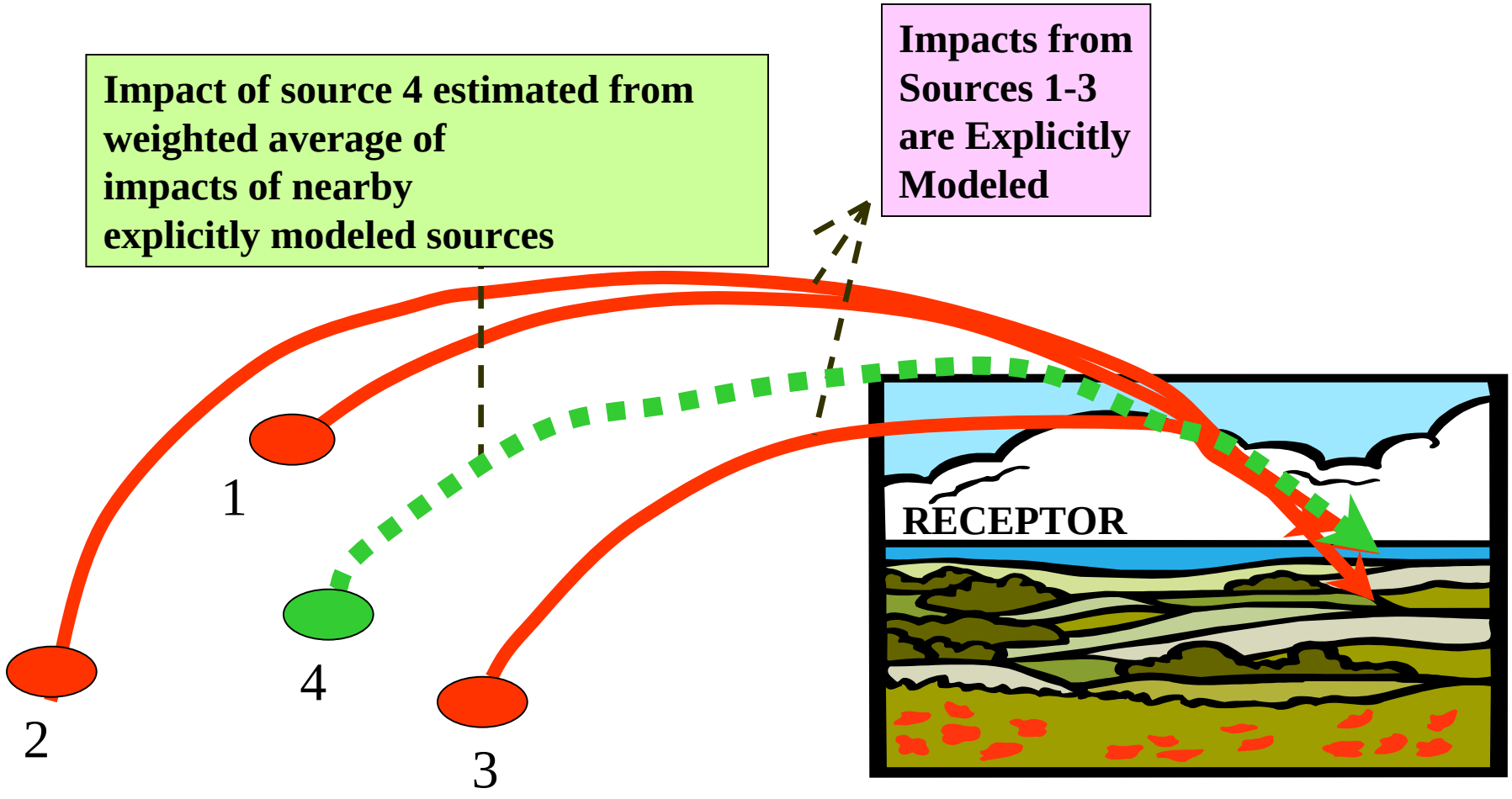
- **For each run, simulate fate and transport *everywhere*, but only keep track of impacts on each selected receptor (e.g., Great Lakes, Chesapeake Bay, etc.)**

- **Only run model for a limited number (~100) of hypothetical, individual unit-emissions sources throughout the domain**

- **Use spatial interpolation to estimate impacts from sources at locations not explicitly modeled**

Spatial interpolation

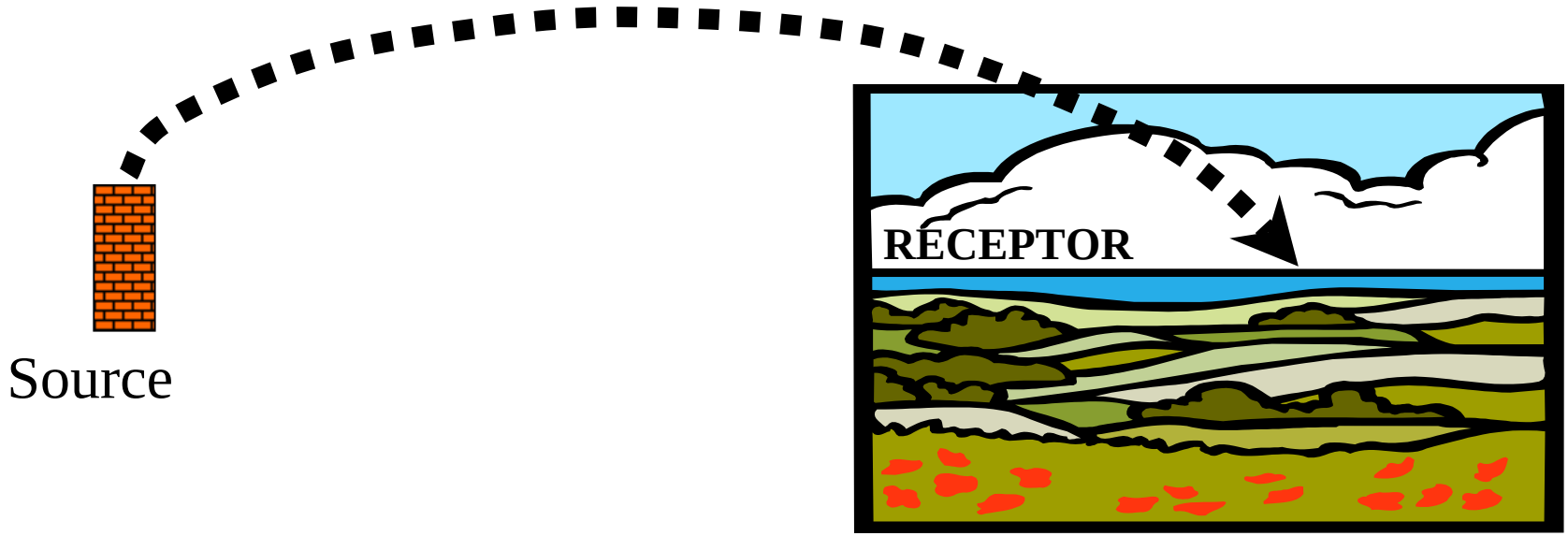


- **Perform separate simulations at each location for emissions of pure Hg(0), Hg(II) and Hg(p)**

  [*after emission, simulate transformations between Hg forms*]

- **Impact of emissions mixture taken as a linear combination of impacts of pure component runs on any given receptor**

“Chemical Interpolation”



Impact of Source Emitting
30% Hg(0)
50% Hg(II)
20% Hg(p)

=

0.3 x **Impact of Source Emitting Pure Hg(0)**

+

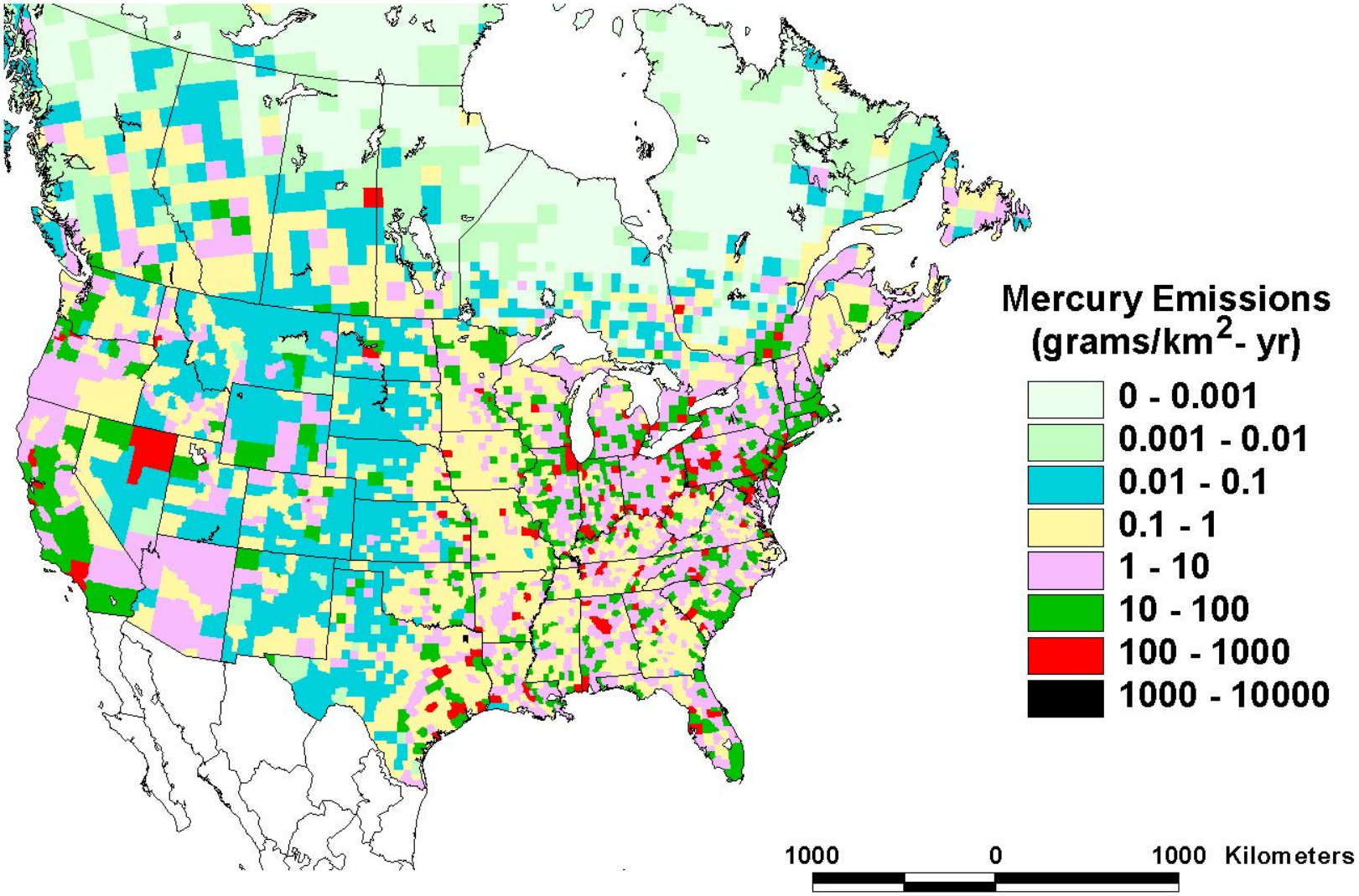
0.5 x **Impact of Source Emitting Pure Hg(II)**

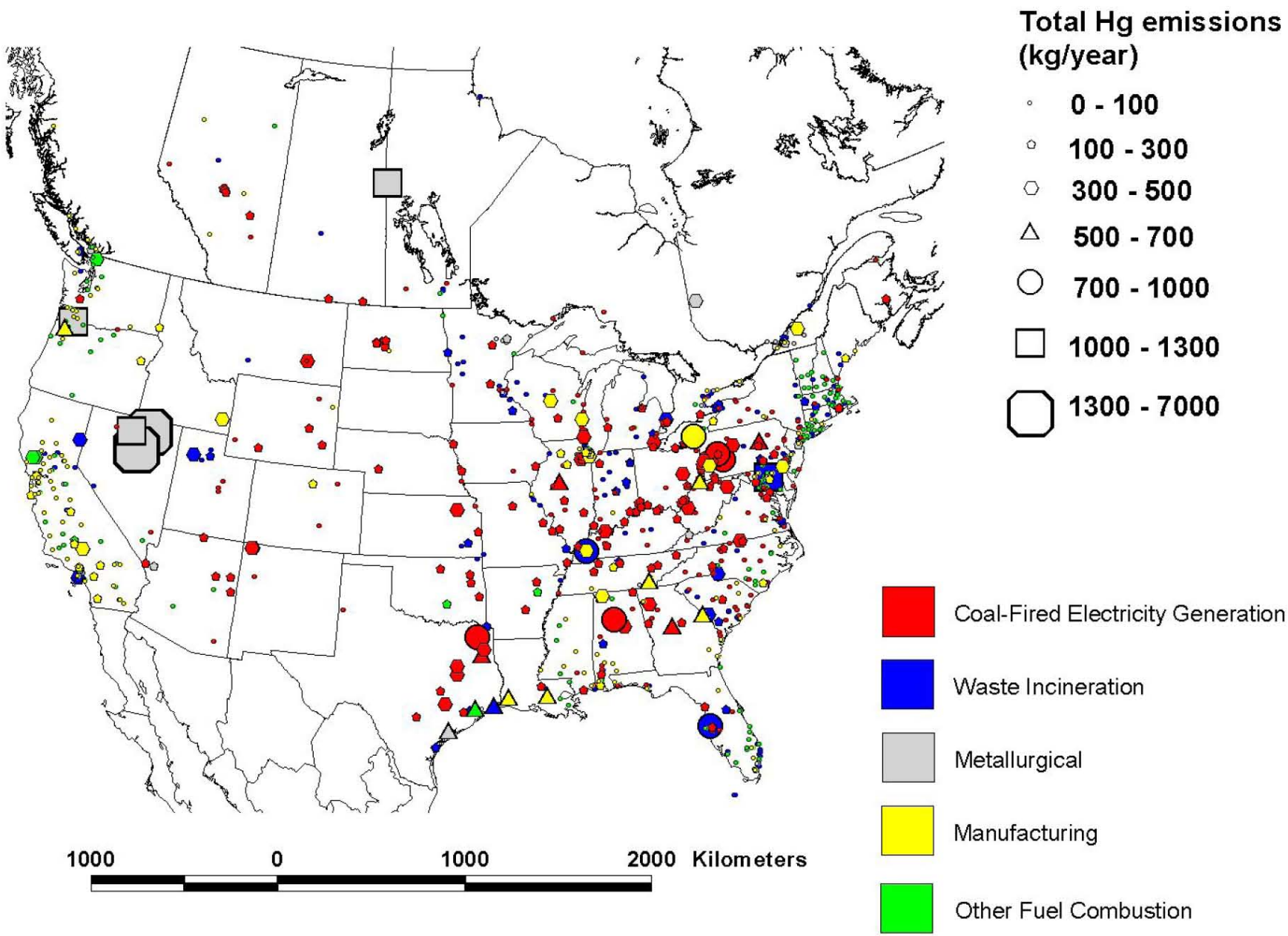
+

0.2 x **Impact of Source Emitting Pure Hg(p)**

Mercury Emissions Inventory

Geographic Distribution of Estimated Anthropogenic Mercury Emissions in the U.S. (1999) and Canada (2000)




Total Hg emissions
(kg/year)
0 - 100
100 - 300
300 - 500
500 - 700
700 - 1000
1000 - 1300
1300 - 7000
Coal-Fired Electricity Generation
Waste Incineration
Metallurgical
Manufacturing
Other Fuel Combustion
1000
0
1000
2000
Kilometers