

APPENDIX D. CUMULATIVE IMPACTS

The term, cumulative impacts, is defined as impacts to the environment that can potentially result from the combined impact of the action when added to other past, present and reasonably foreseeable future actions regardless of which agency or person undertakes such other actions. Thus, cumulative impacts in the context of this document include:

- 1) Impacts inclusive of ongoing or planned carbon sequestration activities that may occur beyond the direct and indirect impacts expected from the DOE's Carbon Sequestration Program (i.e.; activities not sponsored or supported by the DOE). Direct and indirect impacts expected from sequestration technologies have been addressed in Chapters 4 and Appendix C of this document, and they form the baseline for consideration of cumulative impacts described in this chapter.
- 2) Impacts of the Carbon Sequestration Program in context of other Federal and State GHG reduction initiatives.
- 3) Impacts of the Carbon Sequestration Program in context of international GHG reduction initiatives and treaties.

Since 2001, when President Bush announced the GCCI, the DOE and other federal agencies have been, and will continue to, develop programs to devise accounting rules for carbon sequestration projects, provide frameworks for research and development, and provide incentives to land owners or companies that undertake sequestration projects. Other federal agencies that support carbon sequestration activities include USDA, OSMRE, and NOAA.

In addition to programs instituted solely by the U.S. are several international programs that include the participation of other countries as well as the U.S. through the Carbon Sequestration Leadership Forum (CSLF) and through other means.

The following sections provide brief descriptions of non-DOE sponsored U.S. federal, regional, and private sector greenhouse gas reduction and carbon sequestration initiatives as well as international programs, of which some include U.S. participation.

In addition, the predicted amounts of GHG reductions attributable to other DOE and federal programs and policies (as described in the 2002 US Climate Action Report) are included in the discussion of cumulative impacts. The predicted CO₂ emission reductions fostered by these programs are helpful in understanding the potential contribution of sequestration in meeting the GCCI goal.

Also, the United Nations Framework Convention on Climate Change (UNFCCC) has instituted the Kyoto Protocol, which the U.S. has not ratified. Ratification of Kyoto by a country essentially is a commitment to either reduce their emissions of carbon dioxide and other greenhouse gases and/or participate in an international emissions trading market (Wikipedia, 2006).

D.1 U.S. CARBON SEQUESTRATION ACTIVITIES

D.1.1 Federally Sponsored Domestic Carbon Sequestration Programs

D.1.1.1 *FutureGen*

FutureGen will be the world's first zero emissions power plant that will produce electricity and hydrogen from coal, while capturing and storing CO₂. FutureGen will initiate operations around 2012. The plant will be designed to generate nominally 275 MW of electricity (roughly equivalent to an average mid-size coal-fired power plant). FutureGen is a public-private partnership, partially sponsored by DOE. One of the requirements of the project is to generate and sequester at least 1 MMT of CO₂ a year. Once captured, the carbon dioxide would be injected deep underground, into a deep saline formation.

D.1.1.2 USDA Carbon Sequestration Programs

The USDA provides incentives, through financial grants, technical assistance, and pilot programs to private landowners, including farmers and forest and grazing landowners for implementing practices that reduce GHGs and store carbon. Among their major programs are the Environmental Quality Incentives Program, the Forest Land Enhancement Program, Conservation Reserve Enhancement Program, Greenhouse Gas Pilot Projects and the Greenhouse Gas Accounting Protocols.

When President Bush announced his Climate Change Strategy, he challenged USDA to recommend targeted incentives for greenhouse gas offsets from agriculture and forests. The 2002 farm bill provided USDA with the authority and a record level of resources to build partnerships including partnerships that target GHGs. The 2002 farm bill included an increase of more than \$17 billion for conservation, which opens up many more options for many more producers. In 2003, USDA announced a series of actions it would take to increase carbon sequestration and reduce GHG emissions from forests and agriculture. Coupled with the increases in overall conservation spending, these actions are expected to increase the carbon sequestration and greenhouse gas emissions reductions from the conservation programs by over 12 MMTCE in 2012 (see Table D-1). That reduction represents approximately 12 percent of President Bush's goal to reduce GHG intensity of the American economy by 18 percent in the next decade (USDA, 2004).

Table D-1. Estimated GHG Reductions from USDA Targeted Incentives

USDA Action	Estimated GHG Emission Reduction in 2012 (MMTCE)
Revise the Environmental Quality Incentives Program Ranking Criteria to include GHG emission reductions	7.1
On-farm energy generation and GHG reduction from livestock waste management	2.3
Improved nitrogen application practices in agricultural cropping systems	1
GHG management pilot projects	0.5
Forest Land Enhancement Program (FLEP)	0.4
Revise the Conservation Reserve Program Environmental Benefits Index to include carbon sequestration	0.1
Include 500,000 acres of hardwoods in the Conservation Reserve Program	1.0
Total	12.4

Source: USDA, 2003.

Terrestrial sequestration projects promoted under both the USDA and DOE programs would result in net positive impacts to the environment. These land management projects would: 1) sequester carbon; 2) stabilize soils and reduce erosion; 3) decrease fugitive dust emissions; 4) reduce surface water runoff; 5) improve surface and groundwater quality; and 6) create or preserve open space.

D.1.1.3 OSMRE Reforestation Programs

The DOI Office of Surface Mining's Abandoned Mine Lands program provides for the restoration of eligible lands and water mined and abandoned or left inadequately restored. By reforesting abandoned mine lands, the program supports the goals of terrestrial carbon sequestration. There are no published projections on the amount of carbon that would be sequestered by the program.

OSMRE's program of restoring formerly mined lands would result in similar net positive impacts as other terrestrial sequestration projects fostered under both the USDA's and DOE's program.

D.1.1.4 NOAA Carbon Cycle Programs

NOAA has a number of programs focused on investigating the ocean carbon cycle. Their key programs include the Atlantic Oceanographic and Meteorological Laboratory Carbon Dioxide Program, the Pacific Marine Environmental Laboratory Carbon Dioxide Program, and the Global Carbon Cycle Program. NOAA programs focus on research and development to support the carbon sequestration program by assessing the degree and extent of global climate change, determining the ocean's possible role in climate change and the carbon cycle, and developing new monitoring systems.

NOAA's program is not expected to undertake projects that will directly sequester carbon. However, the pure research programs that they support should facilitate advances that make other sequestration programs more efficient and effective, thus, the aforementioned NOAA programs would have net positive impacts to the environment.

D.1.2 Sequestration Projects Sponsored by the Private Sector in the U.S.

D.1.2.1 Enhanced Oil Recovery

Chevron's Rangely Weber Field in Colorado is one of the largest geologic sequestration sites for anthropogenic CO₂. As of 2003, the project injected 2.6 tons/day of CO₂, purchased from a natural gas processing facility in Wyoming. By the time the project is completed, an estimated total of 25MT of CO₂ will be sequestered.

In 2003, over 8 million tons of CO₂ were used for EOR. However, only 10 percent came from anthropogenic sources. The rest was extracted from naturally occurring deposits. It is estimated that up to three-quarters of the CO₂ injected stays sequestered, although further research and development in this area is expected to improve the storage rate to close to 100 percent (NETL, 2003). Subsequently, it is important to note that commercial EOR projects may not be substantively contributing to the reduction of anthropogenic CO₂ in the atmosphere.

D.2 FEDERAL AND STATE GHG REDUCTION PROGRAMS

D.2.1 Federal GHG Reduction or Avoidance Programs

Since the 1990's, the U.S. has made significant progress in reducing greenhouse gas emissions. The government is pursuing the following broad range of strategies to reduce net emissions of GHGs (US Department of State, 2002):

- **Electricity:** Federal programs promote GHG reductions through the development of cleaner, more efficient technologies for electricity generation and transmission. The government also supports the development of renewable resources, such as solar energy, wind power, geothermal energy, hydropower, bioenergy, and hydrogen fuels.
- **Transportation:** Federal programs promote development of fuel-efficient motor vehicles and trucks, research and development options for producing cleaner fuels, and implementation of programs to reduce the number of vehicle miles traveled.
- **Industry:** Federal programs implement partnership programs with industry to reduce emissions of CO₂ and other GHGs, promote source reduction and recycling, and increase the use of combined heat and power.
- **Buildings:** Federal voluntary programs promote energy efficiency in the nation's commercial, residential, and government buildings by offering technical assistance as well as labeling of efficient products, new homes, and office buildings.

- **Agriculture and Forestry:** The U.S. government implements conservation programs that have the benefit of reducing agricultural emissions, sequestering carbon in soils, and offsetting overall GHG emissions.
- **Federal Government:** The U.S. government has taken steps to reduce GHG emissions from energy use in federal buildings and in the federal transportation fleet.

A summary of the estimated CO₂-equivalent GHG reductions gained by implementation of various federal programs, as outlined in the 2002 U.S. Climate Action Report, is provided in Table D-2. Based on the sector totals provided in the report, the U.S. has avoided over 240 MMT of CO₂-equivalent since the inception of these programs. The report also projects that this amount will increase over 2.5 times by 2010. These projections were made assuming a similar level of funding would continue for these programs as that provided in 2002. Based on these projections, it is estimated that combined, these programs could contribute an average CO₂-equivalent reduction or avoidance at a rate of 40 MMT/year (2010 total minus 2000 total divided by 10 years).

Table D-2. Estimated CO₂ Mitigation Impacts of Other Federal Programs

Name of Policy or Measure	Estimated CO ₂ Mitigation Impact for 2000 (MMT CO ₂ Eq.)*	Estimated CO ₂ Mitigation Impact for 2010 (MMT CO ₂ Eq.)
Energy: Commercial and Residential	56.8	Not available (est. 157)
Energy Star® for the Commercial Market	23	62
Energy Star® for the Residential Market	NA	20
Energy Star® - Labeled Products	33	75
Energy: Industrial	27.9	Not available (est. 34)
Energy Star® for Industry (Climate Wise)	11	16
Energy: Supply	14.7	Not available (est. 30)
Clean Energy Initiative	NA	30
Transportation	8.4	Not available (est. 43)
Commuter Options Program	3.5	14
Smart Growth and Brownfields Policies	2.7	11
Ground Freight Transportation Initiative	NA	18
Industry (Non-CO ₂)*	88.7	Not available (est. 325)
Natural Gas Star Program	15	22
Coalbed Methane Outreach Program	7	10
Significant New Alternatives Program	50	162
HFC-23 Partnership	17	27
Partnership with Aluminum Producers	8	10

Name of Policy or Measure	Estimated CO ₂ Mitigation Impact for 2000 (MMT CO ₂ Eq.)*	Estimated CO ₂ Mitigation Impact for 2010 (MMT CO ₂ Eq.)
Environmental Stewardship Initiative	3	94
Waste Management	39.2	Not available (est. 75)
Climate and Waste Program	8	20
Stringent Landfill Rule	15	33
Landfill Methane Outreach Program	11	22
Cross-Sectoral (Federal Energy Management Program and State/Local Climate Change Outreach Program)	6.2	Not available.
All Programs	241.9 (Sector Totals)	1310 (Individual Program Totals)
Sector totals are those reported in Table 4-1 of the 2002 U.S. Climate Action Report. As the report did not project sector totals for 2010, estimated numbers are shown based on the projections for individual programs within that sector. Program specific carbon reduction numbers were obtained within the text of chapter 4 of the same report. Source: U.S. Department of State, 2002.		

D.2.2 State and Regional Programs

D.2.2.1 RGGI

As discussed in Appendix A, nine Northeast and Mid-Atlantic states signed a Memorandum of Understanding to implement the Regional Greenhouse Gas Initiative. The goal of this initiative is to reduce CO₂ emissions by 10 percent of its initial annual budget by 2018. If this goal were attained, collectively the region would reduce CO₂ emissions by 11 MMT from annual baseline levels.

D.2.2.2 State of California

On June 1, 2005, California Governor Arnold Schwarzenegger issued an Executive Order (EO) that established a series of greenhouse gas reduction targets for the state. Included within the EO is a charge for the California Environmental Protection Agency secretary to oversee the efforts to achieve the Governor's standards (State of California, 2005). The EO states targets of:

- Reductions to 2000 levels (370.4 MMT CO₂ Eq.) by 2010;
- Reductions to 1990 levels (322.8 MMT CO₂ Eq.) by 2020; and
- Reductions to 80 percent below 1990 levels (64.56 MMT CO₂ Eq.) by 2050.

D.3 INTERNATIONAL SEQUESTRATION AND GHG REDUCTION INITIATIVES

D.3.1 Carbon Sequestration Leadership Forum (CSLF)

The CSLF is an international climate change initiative that is focused on development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage. The purpose of the CSLF is to make these technologies broadly available internationally; and to identify and address wider issues relating to carbon capture and storage. This could include promoting the appropriate technical, political, and regulatory environments for the development of such

technology. Three types of cooperation are currently envisioned within the framework of the Forum: (1) data gathering; (2) information exchange; and, (3) joint projects. At the second CSLF ministerial meeting in September 2004, 10 joint projects were recognized (DOE, 2004). The U.S. is participating in 7 of the 10 joint projects, listed below:

- *ARC Enhanced CBM Recovery Project (Canada, United States and United Kingdom)*. Evaluate, from both economic and environmental criteria, a process of CO₂ injection into deep coal beds for simultaneous sequestration of the CO₂ and liberation (and subsequent capture) of coal-bed methane.
- *CANMET Energy Technology Centre (CETC) R&D Oxyfuel Combustion for CO₂ Capture (Canada and United States)*. Demonstrate oxyfuel combustion technology with capture of a high-purity CO₂ design and operation of industrial and utility plants based on the oxyfuel concept.
- *CO₂ Capture Project, Phase II (United Kingdom, Norway, Italy, and United States)*. Continue the development of new technologies to reduce the cost of CO₂ separation, capture, and geologic storage from combustion sources such as turbines, heaters and boilers.
- *CO₂ Separation from Pressurized Gas Stream (Japan and United States)*. Evaluate processes and economics for CO₂ separation from pressurized gas streams with gas separation membranes.
- *Frio Project (United States and Australia)*. Demonstrate CO₂ sequestration in an on-shore underground saline aquifer in order to verify conceptual models and monitoring methods, demonstrate that no adverse health, safety or environmental effects will occur, and develop experience necessary for larger-scale experiments.
- *ITC CO₂ Capture with Chemical Solvents (Canada and United States)*. Demonstrate CO₂ capture using chemical solvents, with a goal of developing improved cost-effective technologies for separation and capture of CO₂ from flue gas.
- *Weyburn II CO₂ Storage Project (United States, Canada, and Japan)*. Utilize CO₂ for enhanced oil recovery at a Canadian oil field, including monitoring CO₂ migration within the oil field, with a goal of determining the overall performance and risks in using CO₂ for enhanced oil recovery.

The portions of these projects to be conducted in the U.S. would be similar in size and scope to the model projects developed under this document. Subsequently, impacts associated with these projects would be similar to those predicted in this document.

D.3.2 Tropical Forest Conservation Act

As of June 2004, seven countries have Tropical Forest Conservation Act (TFCA) agreements: Bangladesh, Belize, Colombia, El Salvador, Panama, Peru, and the Philippines. These agreements are offered to eligible developing countries to relieve certain official debt owed the United States while at the same time generating funds to support local tropical forest conservation activities that store carbon. These agreements will generate over \$70 million for tropical forest conservation in countries over the life of the agreements. Based on previous agreements under the TFCA, this funding could preserve approximately 8 to 75 million acres of land in these countries (USAID, 2005). Land preservation resulting from the TFCA would provide net positive benefits to the environment.

D.3.3 President's Initiative Against Illegal Logging

On July 28, 2003, the President's Initiative Against Illegal Logging was launched with the objective of assisting developing countries combat illegal logging, including the sale and export of illegally

harvested timber, and in fighting corruption in the forestry sector. The initiative represents the most comprehensive strategy undertaken by any nation to address this critical challenge to sustainable development, and reinforces the U.S.'s leadership role in countering the problem and preserving forest resources that store carbon (White House, 2004). Forests preserved as a result of this initiative would provide net positive benefits to the environment.

D.3.4 The Kyoto Protocol

The Kyoto Protocol is an amendment to the United Nations Framework Convention on Climate Change (UNFCCC) with the purpose of stabilizing atmospheric greenhouse gas concentrations at levels that would prevent any anthropogenic disturbance of the global climate system. As of January 2006, 160 countries had ratified the agreement without the participation of the U.S. Under the agreement industrialized countries will reduce their emissions of greenhouse gases by a total of 5.2 percent in relation to 1990 emissions levels. The agreement actively came into force on February 16, 2005 (Wikipedia, 2006).

A major component of Kyoto involves an international emissions trading market that allows countries with emissions levels below their set limits to sell credits to countries with levels exceeding their limits. Credits are also received by countries through shared clean energy programs and carbon dioxide sinks, which include forests or other systems that sequester carbon dioxide from the atmosphere (Wikipedia, 2006).

The goals of the Kyoto Protocol are primarily concerned with halting the net increase of atmospheric GHG emissions. Therefore, under the agreement some developing countries will be permitted to increase GHG emissions, which will be offset by reductions employed by currently industrialized nations. Table D-3 lists countries that are included in Annex B of the Kyoto Protocol and their emissions projections based on Kyoto's targets. Countries included in Annex B are developed nations that have agreed to certain targets for GHG emissions and may actively participate in the international emissions trading market. Annex B nations are expected to, in total, reduce their CO₂ emissions by 4.85 percent by 2012 as compared to 1990 emissions levels based on imposed emissions targets (UNFCCC, 2006a).

The highest decision making body within the UNFCCC is the Conference of the Parties (COP), which is an association of all the nations that are parties to the convention. The COP meets yearly to discuss the status of, and potential remedies for, climate change, which includes discussion of Kyoto as well as other longer-term prospects (UNFCCC 2005).

The most recent United Nations Climate Change Conference occurred in Montreal from November 28 through December 9, 2005. During this meeting the eleventh session of the Conference of the Parties (COP 11) was convened. Several substantial decisions came to pass as a result of the conference. The COP decided to adopt the Marrakech Accords, which is considered the rulebook for the Kyoto Protocol, allowing the formal implementation of the Protocol to commence. They adopted a decision that created a formal open dialogue on long-term cooperative action to address climate change, which includes advancing development goals in a sustainable manner, addressing action on adaptation, implementing technology to its fullest potential, and realizing market-based options to their fullest extent. They also established a working group specifically tasked to discuss commitments for developed countries beyond the 2012 commitments currently set forth in Kyoto (UNFCCC 2005).

Due to the fact that the Kyoto Protocol will result in reduced GHG emissions, the implementation of the agreement is expected to have an overall beneficial impact to the environment, although it is acknowledged that further GHG reduction goals and measures are necessary to have a significant impact on global warming.

Table D-3. Estimated Atmospheric CO₂ Impacts of the Kyoto Protocol's Annex B Countries

Party	Baseline 1990 CO ₂ Emissions (Metric Tons) ^a	2003 CO ₂ Emissions (Metric Tons) ^a	Emissions Targets (1990/2012) ^b	Total Emissions Projection for 2012 (Metric Tons)
European Union*	3,111,220,000	3,138,320,000	-8%	2,862,322,400
United States**	3,967,500,000	5,013,460,000	-7%	3,689,775,000
Canada	304,390,000	540,200,000	-6%	286,126,600
Hungary	83,430,000	56,500,000	-6%	78,424,200
Japan	1,038,370,000	1,116,380,000 (1995)***	-6%	976,067,800
Poland	441,880,000	257,580,000 (2002)***	-6%	413,367,200
Croatia	10,350,000	7,630,000	-5%	9,832,500
New Zealand	3,940,000	11,830,000	0%	3,940,000
Russian Federation	2,516,950,000	1,297,260,000 (1999)***	0%	2,516,950,000
Ukraine	699,180,000	257,380,000	0%	699,180,000
Norway	20,950,000	22,250,000	1%	21,159,500
Australia	382,030,000	402,280,000	8%	412,592,400
Iceland	2,080,000	1,970,000	10%	2,288,000
Total	12,582,270,000	12,122,740,000		11,972,025,600
Total CO ₂ Reduction 1990 – 2012 (Metric Tons)	610,244,400			
Net CO ₂ Reduction Percentage (1990-2012)	4.85%			
Total CO ₂ Reduction 2003 – 2012 (Metric Tons)	150,714,400			
Net CO ₂ Reduction Percentage (2003 – 2012)	1.24%			

* The European Union consists of its 15 member States.

** The U.S. has not ratified the Kyoto Protocol as of February 2006.

*** Indicates the most recent year with data available.

Source: ^a UNFCCC, 2006; ^b UNFCCC, 2006a.

D.4 CUMULATIVE IMPACTS OF CARBON SEQUESTRATION PROGRAMS AND POLICIES

The implementation of carbon sequestration technologies that would be expected to cause impacts to the environment, whether under the DOE's program or other federal, state, or private sector initiatives, would be subject to existing federal and state environmental laws and regulations. These regulations principally include the CAA, CWA, SDWA, EPCRA, RCRA, Toxic Substance Control Act (TSCA), the CERCLA, and the ESA. Federal actions would also be subject to additional scrutiny and requirements under NEPA and other acts and executive orders (e.g.; NHPA). Lastly, depending upon the location of a particular action, state and/or local controls could provide additional project-specific controls (e.g.; land use controls, noise ordinances, etc.).

Other U.S. carbon sequestration programs and policies would provide additional means to sequester carbon or sustain or enhance vegetated lands in the U.S. or abroad that currently sequester carbon. Although the scope of carbon sequestration activities being promoted and implemented by the DOE and others have not been fully determined, it is expected that at a minimum these activities would conform to all federal and state laws as applicable. Due to the presence of these laws, acts, and the regulatory programs, the potential for project-specific related impacts when considered on the national scale are expected to be minimal. Subsequently, potential adverse impacts to the environment or human health and safety from the program are expected to be minimal.

The primary area of potential cumulative impacts of these programs and policies would be in the area of land use. Lands in the U.S. used for farming and agriculture would utilize new methods that enhance carbon uptake and retention. Formerly mined lands may receive additional funding to undertake reforestation projects, where the land would be preserved as a carbon sink. There is also the possibility that other types of private or public undeveloped lands would be preserved as carbon sinks in the U.S. International programs and policies (such as TFCA and the Initiative Against Illegal Logging) that serve to preserve land abroad as carbon sinks would complement and advance the goals of the domestic Carbon Sequestration Program.

However, the overall cumulative impact of programs that sequester carbon, including the DOE's program, is expected to provide an overall benefit to the environment, as they would help reduce the accumulation of greenhouse gases that contribute to global warming. Research programs conducted by other federal agencies, like NOAA, USDA and EPA, would also complement the DOE's Carbon Sequestration Program by providing data and tools that would aid future technology development or provide monitoring and data collection mechanisms.

Joint carbon sequestration projects that the U.S. will undertake with other countries, as developed under the CSLF would likely be conducted under, or in coordination with, the DOE's program. These field validation projects are likely to be conducted in part or in whole at U.S. sites. As the U.S. participates in future projects under the CSLF, the DOE's R&D program may be expanded by providing not only additional data to support the program, but may require additional field testing locations and land area in the U.S.

D.5 IMPACTS OF GLOBAL WARMING

While there is serious debate whether or not global warming can be halted or even reversed, there is little doubt that GHG concentrations in the earth's atmosphere are on the increase, with potential linkages to human activities. The rate of the melting of the polar icecaps and the increasing rates of thawing of permafrost in areas like Alaska are expected to increase the rate of global warming – to the extent that global warming may be unavoidable, despite mankind's recent attempts to reduce GHG emissions.

Nonetheless, because of the severity of potential impacts of increased global warming, the U.S. is committed to continuing to take steps through numerous federal programs to reduce anthropogenic CO₂ and other GHG emissions.

According to EPA, as the climate changes, natural systems will be destabilized, which could pose a number of risks to human health (EPA, 1997). Temperature increases, precipitation changes and sea level rise will likely cause: heat waves, air pollution, terrestrial changes, altered marine ecology, storms, droughts, population displacement and saltwater encroachment in coastal aquifers (EPA, 1997). Figure D-1 provides the types of health impacts anticipated from these environmental effects. More information on these effects can be found in EPA circular 236-F-97-005 dated October 1997 titled "Climate Change and Public Health".

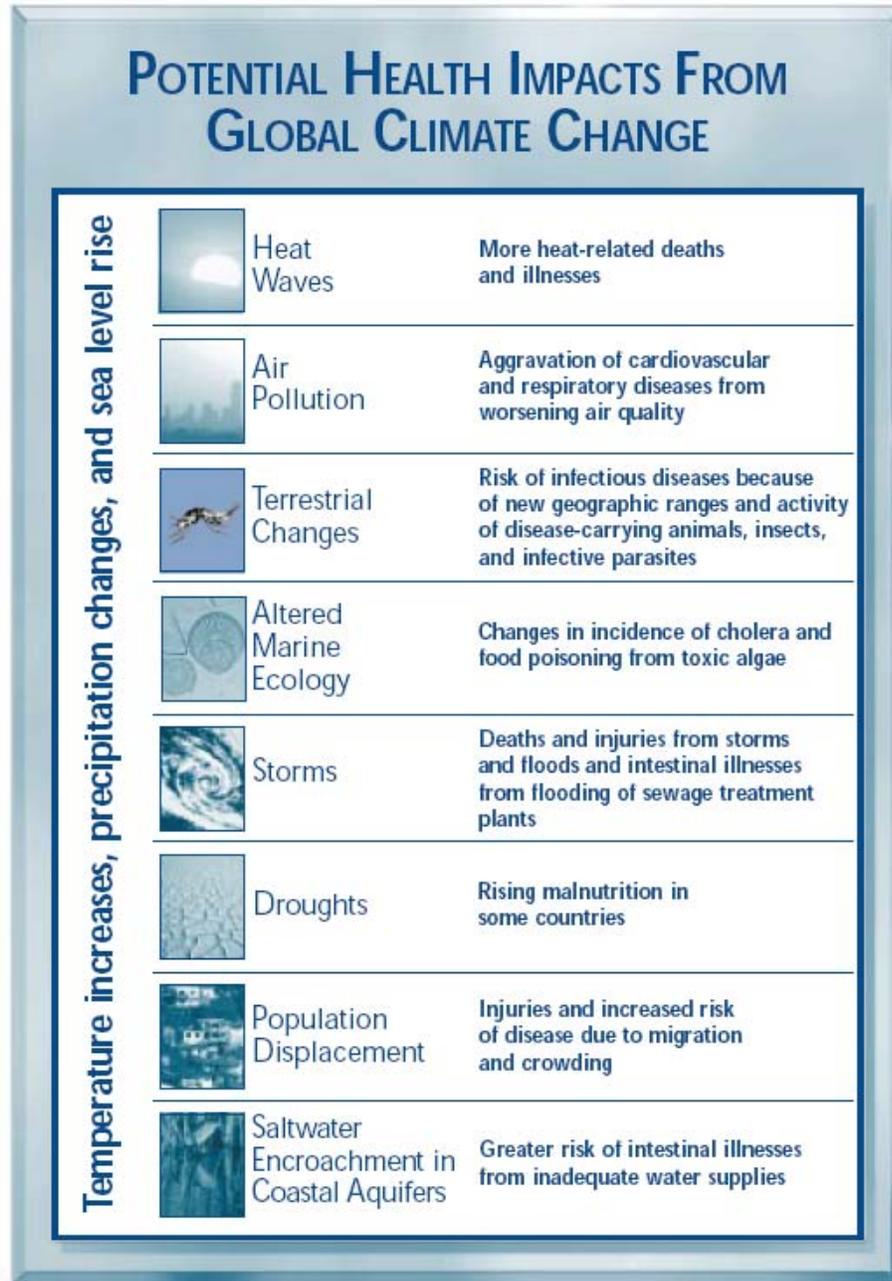


Figure D-1. Potential Health Impacts from Global Climate Change

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