Public Health
Climate Change Adaptation Strategy
for California

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VISION

The Public Health Climate Adaptation Strategy recommends proactive steps to engage people and communities in California to develop resilience and capacity to prepare for changing climate conditions and extreme weather events in ways that promote and protect public health and safety, protect and enhance our natural resources and environment, and promote an equitable and prosperous society.

PURPOSE OF THE DOCUMENT

This strategy is intended, over time, to provide guidance to the many organizations and public agencies that work to improve the health of California's people and the environments in which they live, work, and play. The document is far from complete, but lays the groundwork for future discussions, planning efforts, and actions; it will be revised iteratively as resources allow and new information becomes available.

GUIDING PRINCIPLES[1]

- Promote healthy and resilient populations, communities, and human environments, including reduction of existing health and environmental inequities, to increase preparedness for unavoidable climate change and ability to reduce greenhouse gas emissions.

- Integrate climate change mitigation and adaptation; encourage adaptation strategies that maximize health co-benefits, minimize unintended consequences, and simultaneously mitigate climate change.

- Provide and maintain resources required to implement comprehensive strategies to minimize the impacts of climate change on human health and well-being.

- Increase public awareness and understanding of climate change impacts on human health, the need to prepare for these changes, and the likelihood that adaptation and preparedness efforts will be overwhelmed without also taking urgent and strong actions to prevent dangerous climate change.

- Empower and engage communities for action to mitigate and adapt to climate change.

- Reduce health inequities and ensure health promotion and protection for vulnerable populations and communities.

- Identify and provide research to develop and continually refine comprehensive strategies to minimize the impacts of climate change on human health.

[1] Each of these principles is of equal importance and is listed in no particular order.

FRAMEWORK

The goals of the public health system are to promote health, prevent illness and injury, and protect the health of the population. Health promotion includes addressing the broad social and environmental determinants of health that create the conditions in which people live and allow communities access to the resources required to make healthy choices and promote good health.

Prevention in public health includes:

- Primary prevention: preventing the occurrence of illness and injury through reduction of exposure to risk factors. True primary prevention in climate change is through reduction of greenhouse gas emissions to reduce the severity of climate change impacts (for example the amount of global warming) over time; some experts have called this "primordial" prevention (McMichael, 2000). Reducing climate-change related exposures – for example by shading buildings to reduce heat exposure – are another example of primary prevention.
- Secondary prevention: early detection and slowing the onset or progression of illness. For example, identification of people that might be particularly sensitive to heat and provision of advice and cooling and hydration stations.
- Tertiary prevention is the treatment and management of illness and disability that could not be prevented, such as provision of appropriate health care to those who suffer heat illness in order to prevent severe heat stroke, or management of heat stroke to prevent neurological damage.

These multiple levels of health promotion and prevention are all important in minimizing the adverse health impacts of climate change.

VULNERABILITY ASSESSMENT

Climate scientists predict many changes in California's climate over the next 50 years, including increased temperatures, changes in precipitation (reduced overall precipitation (drought) , decreased snowpack but proportionally more rain), and rising sea level. These changes will have many impacts – direct and indirect – on human health. Human vulnerability to climate change is determined by exposure to climate changes, sensitivity to those changes, and preparedness or capacity to adapt to the changes. Populations that are highly exposed, sensitive, and least prepared or able to respond to climate changes are the most vulnerable.

1. *Exposure to climate changes will vary by geography*. A major challenge in preparing for climate change is that we do not currently have adequate predictions of temperature, precipitation, or sea level rise at the level of detail required for communities to understand more specifically the nature of local climate change risks; "downscaling" climate change scenarios will be an important step in forecasting exposures that will impact human health so that communities can prepare appropriately and adequately. For example, coastal communities will be exposed to sea level rise while mountain communities will not be; some areas of California will be more impacted by extreme heat events or wildfires.

2. *Sensitivity to climate changes will vary by individual and community*. Particular individual or community characteristics may increase the likelihood of adverse health impacts from exposure to climate changes. For example, it is expected that pollen levels will increase with increasing temperatures. People who are allergic to pollens will be more sensitive to that increase than those who are not. Similarly, fair-skinned people are more sensitive to the effects of reduced stratospheric ozone than dark-skinned people. Additionally, infants, the elderly, and people with some chronic illnesses (e.g., heart disease) are more sensitive to very high temperatures. Urban dwellers are more exposed to the effects of urban heat islands; low-income communities may lack access to transportation, health care, and other resources that could help reduce the health impacts of climate change.
3. *Preparedness and response capacity will vary by individual and community*. Individuals and communities differ in their ability to minimize the adverse consequences of climate change. For example, people without cars were unable to evacuate when Hurricane Katrina struck New Orleans. Additionally, people with air conditioners are more able to "adapt" to extreme heat.

Identifying more vulnerable populations - based on high probability of exposure, increased sensitivity, or lack of a capacity to adapt and prepare – will be a critical task in order to reduce the human health impacts of climate change.

Health Impacts of Climate Change

The probable impacts of climate change on health have been well-described elsewhere, and are briefly summarized below. (See, for example, Dreschler D. (2006) and forthcoming update (2008), California Air Resources Board).

- *Temperature changes and extreme heat events*

  California is already experiencing significant changes in average temperatures, and more frequent and severe heat events; these will increase in the future. (Cayan et al., 2008; Gershunov and Cayan, 2008). Scientists predict that average temperatures will continue to increase throughout California, with more pronounced warming of between *1.5°C–6°C (2.7°F–10.8°F)* in the summer months (July – September). Inland region temperature increases will also be as much as *4°C (7.2°F)* higher than warming along the coast. Extreme heat events (heat waves), will increase in frequency and duration, and are likely to affect larger geographical areas and thus more people.

  Health Risks: Ambient temperatures, year-round and seasonal averages, and extreme events, can directly and indirectly influence the health of populations and individuals. Heat-related illness and mortality are directly related to extreme heat events. Three examples of potential indirect effects of altered average temperatures are: (1) impacts on agricultural production, food availability, quality, and costs; (2) influence on geographic range and seasonal activity of vector-borne disease pathogens, vectors, and host species (discussed below); and, (3) winter warming may lead to precipitation shifting from snow to freezing rain or ice, posing greater roadway hazards.

Heat Stress and Heat-Related Illness: Physiologic mechanisms maintain the core body temperature (i.e., the operating temperature of vital organs in the head or trunk) in a narrow optimum range around 37º C (98.6 °F). When core body temperature rises, the physiologic response is to sweat and circulate blood closer to the skin's surface to increase cooling. Any individual, regardless of age, sex or health status can develop heat stress if exposed to sufficient environmental heat (and humidity) and/or engaged in intense physical activity.

If heat exposure exceeds the physiologic capacity to cool, and core body heat rises, then a range of heat-related symptoms and conditions can develop – from the relatively minor treatable conditions *heat-related cramps, syncope, and edema* (which should be used as important warning signs to immediately remove the affected individual from the exposure situation), to more serious *heat exhaustion* that results from extreme depletion of blood plasma volume and requires immediate treatment because if allowed to progress it can lead to *heat stroke,* the most serious form of heat-related illness.

Heat stroke is an extreme medical emergency that if untreated can result in death or permanent neurological impairment. Heat stroke occurs when a person’s core body temperature rises above 40°C (104°F) as a result of impaired thermoregulation. High core body temperature can lead to damage in vital organs, such as the brain, liver, and kidneys, which in turn can result in serious illness, neurological damage, and death.

For the average healthy individual, over a period of one-to-two weeks, exposure to conditions that elevate body temperature -- physical activity and/or environmental heat results in a process of physiological adaptation, called “acclimatization.” When acclimatized, the body produces more dilute sweat, and heart rate and body temperature increase less than when not acclimatized. Even when acclimatized, adequate hydration is critical to avoid development of heat-related illness.

Less healthy individuals may not be able to fully acclimatize and therefore remain at elevated risk. The elderly, infants, and individuals with pre-existing illness such as cardiovascular disease are at increased risk of heat-related illness. Additionally, a wide variety of prescribed and over-the-counter medications may interfere with thermoregulatory processes or contribute directly to dehydration also increasing the risk of heat-related illness even when ambient heat does not appear excessive.

Case studies in extreme heat events: Extreme heat events are already becoming both more frequent and more severe. In 2003, a severe heat wave across Europe is estimated to have led to 35,000 deaths. In 2006, California suffered a heat wave of unprecedented intensity, duration, and geographic area (Gershunov & Cayan, 2008). During this event, there were approximately 140 coroner’s reports of deaths attributable to heat-related illness (Kim et al, 2007; Margolis et al, 2008); more than 600 excess deaths occurred over a two-week heat wave period (Ostro et al, 2007). Additionally, there were nearly 1,200 excess hospitalizations and more than 16,000 excess Emergency Department visits (Knowlton et al, 2008). In this study, children (ages 0 – 4 years) and the elderly (ages ≥ 65 years) were at greatest risk. Surprisingly, the highest risk of heat-related illness occurred in the usually cooler region of central coast counties and not in the central valley where the highest actual temperatures were experienced. This finding points to the importance of population acclimatization and adaptive capacity (such as access to cooled indoor environments) in the degree of risk posed by extreme heat events. Events of this nature may be the heat waves of the future. (Gershunov & Cayan, 2008)

Recent studies also suggest an increase in mortality associated not only with extreme heat waves, but also with less acute temperature increases. Ostro & Basu found that a 10°F increase in mean daily apparent temperature corresponded to a 2.6% increase for cardiovascular mortality; risks were greater for persons over 65 years of age, infants less than a year, and African-Americans. (Basu R, Ostro BD. *A multicounty analysis identifying the populations vulnerable to mortality associated with high ambient temperature in California*. Am J Epidemiol. 2008; 168(6):632-7)

Urban Heat Islands: Cities and other urbanized areas are significantly hotter than adjacent suburban or rural areas – by as much as 8 degrees F (LBL 2008). This "Urban Heat Island" is due to the greater heat retention of buildings and paved surfaces compared to vegetated surfaces. During heat waves, urban heat islands are especially dangerous because they are both hotter during the day and do not cool down at night, increasing the risk of heat-related illness. Urban heat islands also increase energy consumption for cooling, with consequent increased energy production and related air pollutant emissions; moreover, as discussed below, higher air temperatures increase ground level ozone levels.

Health Inequities Issues: Several factors could contribute to health inequities related to increased heat exposure:

a. Chronic illness comorbidities: Low income and minority communities have an increased prevalence of chronic illnesses that place individuals at greater risk of heat-related illness.
b. Exposure to urban heat island effect: low-income individuals and people of color are often concentrated in urban areas subject to the heat island effect.
c. Access to air-conditioning: low income individuals and people of color are less likely to have air conditioning.
d. Occupation: Agricultural workers are especially at risk of heat illness due to the combination of outdoor work in hot climates (e.g. Central and Imperial valleys) and jobs demanding physical exertion.

Several studies have shown increased risks of heat illness and heat mortality in low income and minority communities, agricultural workers, and especially in the homeless. For a more detailed vulnerability assessment on heat-related illness, see http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf

- *Extreme heat and cold events*: Greater and more frequent extremes of heat and cold are expected due to climate change, putting more outdoor (and possibly indoor) workers at increased risk of heat/cold-related illness including death. Public health systems need to be put into place to track temperature-related illness, investigate serious worker illnesses and fatalities, and get the word out to employers and employees on how to prevent serious temperature-related illness. We expect the extent of this problem to be increasing, and there may be more occupations and industries affected than previously, or new risk factors or circumstances identified as contributing to illness. Therefore, added efforts will be needed to promote implementation of safety measures to protect affected worker populations.

- *Stratospheric ozone depletion, skin cancer, and cataracts:* Stratospheric ozone is a critical compound which protects the earth's surface from harmful ultraviolet radiation. As climate change causes increased surface temperatures, the stratosphere has cooled, making repair of the ozone layer slower. This depletion of the stratospheric ozone layer allows more ultraviolet light to reach earth's surface, increasing human exposure to ultraviolet radiation.

  Human health effects from ultraviolet radiation exposure include increased risks of skin cancer (melanoma and non-melanoma), cataracts, and suppression of the immune system (CIESIN). It is likely that malignant melanoma rates will increase; the World Health Organization has estimated a 10% increase in skin cancer in the U.S. by 2050 due to continued ozone depletion (van der Luen and Guijl, 2002; WHO, 2008). UV exposure also accelerates aging of the skin. UV damage reduces the immunological defenses of the skin, reducing resistance to infectious disease and lessening the effectiveness of vaccines. Skin color, age, geographical latitude, and occupational and recreational activities impact exposure to sunlight and UV radiation, and thus the risks of UV-related health effects.

  References
  Van der Leun J and Guijl F. *Climate change and skin cancer*. Photochem Photobiol. Sci., 2002, 1, 324 - 326, DOI: 10.1039/b201025a

  WHO. Climate Change and Human Health.
  http://www.who.int/globalchange/climate/en/ accessed 11/14/08

  http://www.ciesin.org/TG/HH/ozover.html

- Air pollution and allergens

  Air pollution: Air pollution currently has very serious public health consequences. Ground-level (tropospheric) ozone can cause decreases in lung function and increase airway reactivity and inflammation. Particulate matter can aggravate existing respiratory and cardiovascular disease and damage the lungs, leading to premature death; it may also contribute to increased risk of cancer. According to the California Air Resources Board (CARB), current exposures to just two common air pollutants – ozone and particulate matter (PM) cause around 8,800 deaths, 9,500 hospitalizations, 200,000 cases of asthma and lower respiratory symptoms, and nearly 5 million school absences in California each year.
  (www.arb.ca.gov/research/health/qhe/qhe.htm). Other air pollutants – such as sulfur and nitrogen oxides – also affect the respiratory and cardiovascular systems.

  Changes in temperature affect atmospheric chemistry and the amount of some pollutants like ozone that are in the air. The relationship between temperature change, air quality and human health is complex and synergistic. Four specific dimensions of the relationship have been studied to different degrees: 1) direct effects of temperature on health; 2) direct effects of air pollution on health; 3) temperature and geographic factors that modify pollution effects on health; and 4) pollution factors that modify temperature effects on health.

Climate change can affect exposure to air pollution in several ways:

1. Increasing air temperatures increase ozone levels, which are formed by reactions between nitrogen oxides and hydrocarbons released from motor vehicle combustion of fuel.
2. Increasing temperatures can change human behavior in ways that increase air pollution – for example, through increased fuel combustion to meet electricity demand for increased air conditioner use
3. Climate change can effect patterns of air mixing and air flow that transport pollutants
4. Increased temperatures can increase the emission of pollutants called volatile organic compounds from plants and vegetation.

Knowledge of air pollution direct health effects has resulted in regulations for criteria air pollutants and hazardous air pollutants. Changes in air pollutant levels due to temperature changes will result in more non-attainment days and greater risks of disease to the involved populations. Recent research suggests that changes in temperature and geographic location will further modify the effect of air pollutants on respiratory and cardiovascular health and mortality. Conversely, it has been demonstrated that changes in ozone or particulate matter levels modify the effect of heat on cardio-vascular mortality.

One recent study estimated that each one degree (Celsius) increase in temperature would cause about 1000 additional deaths in the U.S. associated with air pollution. (Jacobson M. *On the causal link between carbon dioxide and air pollution mortality*. Geophy Res Let (2008)
http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overviewhealth.htm#Air%20Pollution-related%20Health%20Effects

Ebi KL, McGregor G. Climate Change, *Tropospheric Ozone and Particulate Matter, and Health Impacts***.** Env Health Persp (2008) 116:1459-1455
Kristie L. Ebi[1] and Glenn McGregor
http://www.ehponline.org/docs/2008/116-11/toc.html

Aero-allergens: Both increased temperatures and increased carbon dioxide concentrations are expected to increase plant production of pollens, and may also increase fungal growth and spore release. Pollen and mold spores are allergens; they can induce and/or aggravate allergic rhinitis, asthma (already the most common childhood chronic illness), and chronic obstructive pulmonary disease. Allergic diseases are the sixth leading cause of chronic disease in the U.S. and impose a substantial burden on the U.S. population. Some experts have suggested that the global rise in asthma is an early health effect of climate change. (http://www.cdc.gov/climatechange/effects/allergens.htm)

Health Equity Issues: Air pollution levels in poor urban neighborhoods are often substantially higher than those in other areas, due to closer proximity to freeways and other motor vehicle arterials, and industrial pollutant sources. Asthma rates are higher in low income and minority children in California. Increases in air pollutants and/or aero-allergens may exacerbate these existing health inequities, unless special care is taken to reduce pollution sources; recent action by the CARB to reduce diesel truck pollution is a good example of a policy that could reduce these health inequities. http://www.hc-sc.gc.ca/sr-sr/finance/tsri-irst/proj/urb-air/tsri-223-eng.php

- Water and health

Drought: Climate change has already had a significant impact on the frequency and magnitude of drought periods in the State of California; more frequent drought periods are likely in the future. The snowpack in the Sierra Nevada serves as the State's largest water "reservoir" that typically enters the stream and river systems in the late spring and summer as it melts. As the Sierra Nevada snowpack decreases, ensuring the availability of drinking water and other water supplies will be increasingly challenging; diminished snowpack will also increase flooding, with significant risks to water systems (see below).

Drought impacts drinking water quality by increasing salinity, dissolved solids, algal and bacterial growth, and chemical contaminant concentrations; additionally, drought pushes water management agencies to seek new water supply sources, including through recycling, desalination (of brackish groundwater or seawater), or use of groundwater of lower quality.

As the amount of surface water supplies are reduced as a result of drought conditions, the amount of groundwater pumping that occurs is expected to increase to make up for the shortfall. This has the potential to result in dropping water tables and land subsidence. Communities that utilize well water will be adversely effected both by drops in water table or through changes in water quality. The increased use of ground water will also likely expand disputes over water rights, with concomitant increases in stress levels

Salinity: Drought causes a decrease in the amount of surface water available in both rivers and reservoirs. Reduced flow in rivers that feed the Delta has led to significant increases in salinity of water, due to reduced volume of low salinity snow melt; salinity is also increased due to the larger percentage of flow from treated wastewater discharge, and the influence of groundwater pump-in used to secure additional water resources for southern California.

Dissolved solids: Diminished surface water availability due to drought will increase demand on groundwater supplies, which generally have higher total dissolved solids than surface water. The use of drinking water supplies with higher dissolved solids will have several effects: (1) a negative impact on consumer acceptance; (2) increased costs associated with mineral deposits in water heaters and other plumbing fixtures; and (3) elimination of blending as a solution for many public water systems that rely on the low salinity Delta water to enable use of local water supplies with high solids.

Algal and bacterial growth: As the water levels in reservoirs decrease due to prolonged drought periods, the likelihood for increased algae growths and also warmer water temperatures will occur. The warmer water will likely support a different set of bacteria than is found in colder waters. The possibility exists that pathogens that thrive in warmer waters, which historically have not been present, may be detected in the drought-impacted supplies.

Chemical contaminants: Individual chemical constituents could also occur at higher concentrations during drought periods. Likely problem constituents are nitrates and arsenic, both of which are inorganic chemicals that can be present above drinking water standards in groundwater pumped into the California Aqueduct. Systems that have balancing reservoirs above their intake structures may address this problem by blending the water in the reservoirs with water diverted from the Aqueduct to reduce overall concentrations of nitrate and arsenic to below their respective maximum contaminant levels. This may not occur for systems that have intake structures directly on the canal without any reservoirs for balancing.

Recycled water: Increased use of recycled water will elevate the potential for public health exposure if improper treatment occurs. Many uses of recycled water are being explored that have not previously been approved in California. Review and approval of these projects will be necessary along with an updated regulation package for recycled water that is sufficiently protective of public health.

Rising sea level and salinity: Rising sea levels will extend the fresh water/salt water transition zone farther inland. This will increase the salinity of water sources located in coastal areas, in the San Francisco Bay Area, and in the Sacramento Delta. More wells will be subject to salt water intrusion and will need to be abandoned, treated to reduce salinity, or protected by salt water intrusion barriers. (The latter are created by injecting fresh water or highly treated recycled water between the wells and the shoreline.)

Surface water sources in these areas will either have to be treated to reduce salinity, or the intakes will have to be moved father inland and out of the zone of saltwater intrusion. In cases where salt water intrusion does not drive salinity to excessive levels, there may still be problems with disinfection byproducts (e.g., bromate) caused by the presence of bromide in salt water.

Many Californians receive their drinking water from private wells along the California coastal regions. Sea level rise may affect freshwater quality by increasing the salinity of coastal rivers and bays and causing saltwater intrusion.

Diminished snowpack, increased flood flows, and water systems: Increased rainfall and reduced snowfall is expected to challenge the existing raw water infrastructure –

reservoirs and conveyance structures. The flood flows may overwhelm the Delta levees which already are considered vulnerable due to lack of maintenance.

During these flooding events, there may not be sufficient freeboard in the raw storage reservoirs to capture the flood flows that will then be discharged through the Delta into the Bay. The ability to capture this water for use during the summer and late fall is doubtful. Drinking water suppliers will be challenged to meet their summer demands without the capture of this water supply.

The flood waters can be expected to contain excessive levels of turbidity, which will challenge many of the existing surface water treatment facilities that were designed to handle waters with typical historical raw water quality. Improvements to chemical feed and solids handling facilities may be required to ensure that proper treatment is provided to meet drinking water standards during flood flow conditions. These flows will likely occur throughout the winter and spring precipitation periods.

There is also the likelihood that the storm flows may cause overflows of marginally treated wastewater or raw wastewater. This will increase the pathogen loadings in the source waters and require increased disinfection of the water delivered to drinking water systems. This, in turn, will increase the disinfection byproduct compliance problems faced by the water supply utilities.

Another concern with a reduced snowpack is the possibility for insufficient recharge of hardrock wells in mountain communities. With more of the precipitation events occurring as rain, the ability to infiltrate and recharge the hardrock areas is unknown. Many communities may not be able to rely on their hardrock wells in the late summer and fall because of insufficient recharge. This potentially could affect the quality of the groundwater supplied by the hardrock wells and they may be more susceptible to influence from septic tanks and leach fields.

In summary, California’s future water supply plans are likely to be severely challenged by climate change. Options for meeting these challenges are likely to depend on increased conservation, water reuse, and desalination where feasible.

- *Recreational waters*:

It is anticipated that global warming will have a major impact on the recreational waters of California, through drought or significant rainfall events. Variable weather patterns may also affect the recreational waters by changing the geography of lakes, rivers, streams, beaches, bays and estuaries. Increased water pollution from urban runoff, elevated levels of disease causing pathogens, and loss of recreational water areas due to flooding are other potential negative impacts.

It is likely that more of the state’s precipitation will be in the form of rain rather than snowfall because of warmer temperatures. Runoff from urban watersheds can contain elevated concentrations of pathogens that can negatively impact water quality of both fresh and marine bodies of waters that receive the runoff. The concentrations of pathogens responsible for recreational water illnesses can increase in the runoff, especially during wet weather conditions. Contributors to the increased pathogen load in the storm water can include sanitary sewer overflows from waste water treatment collection systems and treatment ponds, failing sewage disposal systems, flooded cattle grazing areas or flooded concentrated animal feed lots. Some pathogens and viruses responsible for recreational water illnesses can live for extended periods of time once introduced into fresh and marine environments.

Recreational water illnesses usually result from swallowing, breathing, or having contact with contaminated water. Symptoms of recreational water illnesses can include gastrointestinal, skin, ear, respiratory, eye, neurological and wound infections. Recreational users who swim, surf or participate in boating at the marine or fresh waters that are contaminated with pathogens can be exposed to a variety of recreational water illnesses. The most common recreational water illness is diarrhea. Dirraheal illnesses can be caused by pathogens such as Cryptosporidium, Giardia, Shigella, norovirus and E. Coli 0157:H7. Children, pregnant women, and people with compromised immune systems can suffer from more severe illness if infected.

Naturally occurring pathogens: More rainfall increases the risk of flooding. Flooding combined with increased water temperatures can result in human exposure to naturally occurring pathogens responsible for recreational water illnesses. Increased water temperatures, combined with decreased salinity from greater rainfall, could result in increases of Vibrio *vulnificus* bacterium along the coastal waters of the state that are now currently found predominantly in the warm waters of the Gulf of Mexico. In 2005 there was an increase in reported cases of Vibrio infections that can be attributed to flood water exposure in the Gulf Coast immediately following Hurricane Katrina. The reported hurricane-related infections were primarily among persons with wounds who waded through flood waters. The majority of hurricane-related Vibrio infections were caused by *V. vulnificus*, which predominately occurs in the Gulf Coast. Wound infections from *V. vulnificus* can cause severe illness including septicemia and the need for amputation. V. *vulnificus* is a bacterium in the same family as those that cause cholera. Illness is more common and severe among persons with preexisting wounds and other medical conditions (e.g., diabetes, heart disease, or liver disease). *V. parahaemolyticus* and nontoxigenic *V. cholera* infections were also reported among persons with hurricane-related *Vibrio* infections. Increased water temperatures could lead to an increase in the frequency and distribution of other naturally-occurring pathogens such as *V. parahaemolyticus* which currently exists along the coastal waters of the state.

Blue Green Algae: More variable weather patterns may also result in increased dryness in certain regions of the state. This dryness and warmer temperatures can result in favorable conditions leading to increased occurrences of Blue Green Algae (BGA) blooms in fresh water rivers and lakes used for recreational purposes. Some BGA are noted for their ability to produce deadly toxins such as neurotoxins, hepatotoxins or compounds that cause allergic responses. BGA neurotoxins can kill animals within minutes by paralyzing the respiratory muscles, while the hepatotoxins can cause death within hours. Although the occurrence of BGA toxins in the freshwater environment is unpredictable, blooms may persist for up to seven days but the resulting toxins may last for as long as three weeks. BGA are not always visible and can move up and down the water column and may not always float to the surface. Currents and surface winds can push them toward the land, causing the toxin filled cells to accumulate near the leeward shore or beaches. Low flow river conditions in the summer and fall may result in large build-ups of BGA. When the BGA cells die or are damaged, toxins can be released at harmful levels to pets and livestock if they drink the water or eat the algae. Blooms are most likely to form when water is warm and the water contains an abundance of nutrient nitrogen and phosphorus. Contributors of these two elements can be from agricultural or urban runoff or failing sewage disposal systems. Human poisoning is infrequent because people tend to avoid swimming in waters full of algae and ingesting the BGA. Children and infants are more susceptible to the ill effects from exposure. Deaths are rare but in one case BGA-contaminated water used for liver dialysis produced over fifty liver failure fatalities in Brazil. Most exposures are through oral, dermal, or intra-nasal contact. Swimmers and even boaters on water containing BGA can experience skin irritation, gastrointestinal symptoms, and other reactions such as eye irritation, asthma, pneumonia, and hay fever symptoms.

The Klamath River in northern California has recently been affected by severe BGA. The blooms have resulted in the release of health advisories by local officials, including recommendations to avoid body contact with the water, particularly in reservoirs used for fishing and boating activities. In this case, the BGA, besides posing a health risk, pose an economic risk to area, which relies on recreation as an important part of the community livelihood. Furthermore, the blooms have interfered with the cultural practices of local Native American tribes that use the river for ceremonial purposes.

Loss of acquatic recreation sites: Sea level has risen about seven inches at the Golden Gate Bridge in the last century, and continued sea level rise could threaten or eliminate many coastal beaches used for recreation. Many ocean shores are currently eroding 1 to 4 feet per year. Although some new beaches may form, public access to these may be limited. Additionally, defensive measures that people take to protect private property from rising sea level such as installation of bulkheads, sea walls or barriers along shorelines can have adverse effects on public access to beaches and coastal water.

Loss of access to outdoor recreation sites such as beaches, lakes, and rivers may impact recreational physical activity levels, as well as reduce opportunities for social networking and stress reduction.

Health equity issues: Increasing the challenge of adequate drinking and other water supplies is likely to put pressure on the cost of drinking and household water, which will disproportionately impact low income communities that already spend a higher proportion of their income on necessities. Diminished access to free or low cost public recreational areas such as beaches and lakes may also have a greater impact on low income families who cannot afford access to private swimming pools, etc.

- **Wildfires**

Wildfires consume an average of five million acres yearly in the U.S.; wildfire economic losses in California are higher than any other state, in part because of the extent of the urban-wildland interface. Climate change – with warming, drought, and wind changes that can fan fires – is likely to increase the severity, frequency, and extent of wildfires, and lengthen the fire season.
http://eetdnews.lbl.gov/nl9/Climate.html

The health and human impacts of wildfires include burn injuries, eye, nose, and respiratory irritation, exacerbation of asthma, carbon monoxide poisoning, post-traumatic stress disorder, and displacement; additionally, ash in burned structures has recently been determined to be hazardous. See "Wildfire Smoke: A Guide for Public Officials" http://www.oehha.org/air/risk_assess/wildfirev8.pdf

Particulate matter in smoke is the principal public health threat from short-term wildfire smoke exposure; particulate matter is associated with increased premature mortality and aggravation of pre-existing respiratory and cardiovascular disease, and can affect the mechanisms that remove inhaled pollen and bacteria from the lungs.

Individuals with asthma, chronic obstructive pulmonary disease, and cardiovascular disease are more sensitive to wildfire smoke than others. Children, with developing lungs, may also be more sensitive to smoke.

Carbon monoxide, a gas that reduces oxygen delivery to cells in the body, is likely to be a significant hazard only to people very close to the fire line, or sensitive individuals such as those with cardiovascular disease. CO may exacerbate cardiovascular disease; at high levels, CO poisoning can cause headache and neurological impairment.

In general, the long-term risks from short-term smoke exposures are quite low. Short-term exposures to wildfire carcinogens (e.g. PAHs) are small relative to total lifetime exposures to carcinogens in diesel exhaust and other combustion sources. Urban firefighters exposed to smoke over an entire working lifetime have about a three-fold increased risk of developing lung cancer.

The community health impacts of prolonged wildfire smoke exposure – as was experienced, for example, in the Butte fire of 2998 – have not been well studied.

References
Advice on how to reduce exposure to smoke in areas impacted by wildfires is available at: http://bepreparedcalifornia.ca.gov/NR/rdonlyres/63FB9486-13B4-419A-90D2-98921D5C817F/0/WildfireSmokeAGuideforPublicHealthOfficialsRevisedJuly2008FINAL.pdf

Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems Final Report, Synthesis and Assessment Product 4.6, by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, July 2008.

Sea Level Rise: Sea level rise is expected to force thousands of people to permanently relocate, especially in coastal and delta areas. Protection of low-lying areas with sea-walls or reinforced levees will be very expensive, if possible.

Flooding/Drowning: Rising sea levels, reduced snowfall, increased intensity of rainstorms, and increased desertification with flash floods will all increase the risk of flooding in California. Flooding associated with breached levees or dams (e.g. in the Sacramento-San Joaquin Delta) can also put large populations at risk. Drowning may occur as people are overcome by rising waters, caught and washed away in vehicles, or try to recreate in flood waters.

Flood waters may contain household, industrial and agricultural chemicals as well as sewage and animal waste. Flooding and heavy rainfall events can wash pathogens and chemicals from contaminated soils, farms, and streets into drinking water supplies. Flooding may also overload storm and wastewater systems, or flood septic systems, also leading to possible contamination of drinking water systems. Overloaded wastewater treatment plants may release raw sewage into streams or rivers, or into flood waters that pose a risk to people who come into contact with the waters. Longer term, flooding increases contamination of buildings with molds associated with respiratory illness.

Displacement: Displacement may be temporary (as in flooding or other extreme weather events) or permanent (as in sea level rise or some extreme events such as Hurricane Katrina). When evacuation is required due to an imminent weather event, movement of evacuees will stress transportation corridors; if highways are flooded, evacuation will be problematic. Evacuations will result in requirements for food, drinking water, sanitation facilities shelter, and health care. As the number of evacuees' increases, or the length of time of the evacuation increases, meeting those requirements becomes increasingly difficult. Loss of electric power will exacerbate the situation. People who are unable to evacuate will require transportation; those in hospitals, residential care facilities, and other institutions will have special transportation requirements and special needs in evacuation centers. If people are trapped in their residences, emergency responders will need to seek them out and relocate them. Permanent relocation disrupts family and social networks, and causes economic hardship.

Nuclear reactors: Sea level rise and severe storm surges may also be a concern due to the current locations of California's two nuclear power plants relative to the Pacific Ocean: San Onofre Nuclear Generators (Orange County) and Diablo Canyon Nuclear Power Plant (San Luis Obispo County). Power plant operations could be impacted in several ways: flooding of the facility's containment buildings which store the highly radioactive spent nuclear fuel would be compromised thereby releasing their contents into the environment; extensive erosion of the property due to flooding caused intrusion of sea water resulting in an unsustainable facility; and other severe damage to the facility that would cause a significant or total loss of generating power. Additionally, rising ocean temperatures may impact nuclear power plant cooling practices.

- Vectors and health

Changes in temperature and precipitation are likely to cause changes both in the geographic distribution and the quantity of vectors (such as ticks and mosquitoes) that carry human disease. In California, three main vector-borne diseases of concern that climate change may impact include human hantavirus cardiopulmonary syndrome (HCPS), Lyme disease, and West Nile virus. An increase in summer rainfall could make California more at risk for the introduction and establishment of exotic vectors such as *Aedes aegypti* and *Aedes albopictus*, the principle mosquito vectors for other flaviviruses such as dengue and yellow fever. With regard to mosquito-borne diseases, CDPH-VBDS promotes the California Mosquito-borne Virus Surveillance and Response Plan (www.westnile.ca.gov) to help local agencies assess and predict risk of mosquito-borne diseases in their area

The deer mouse, *Peromyscus maniculatus* is the main small rodent reservoir for hantavirus and is ubiquitous throughout California in undeveloped areas. During heavy precipitation periods, food supplies increase, resulting in rodent population growth. It has been hypothesized that the 1992-1993 El Niño weather patterns were associated with an outbreak of human hantavirus pulmonary syndrome (HCPS) in the southwestern U.S. (Engelthaler, et al., 1999), though this suggestion remains under discussion by hantavirus researchers (Boone et al., Am. J. Trop. Med. Hyg. 67 (3); 2002:310-318). Although HCPS infections have remained rare in California, more common flooding or heavy precipitation cycles could increase infected deer mice populations. People at risk for infection are those who are exposed to rodent-infested dwellings particularly in undeveloped areas where *P. maniculatus* is abundant, such as poorly maintained mountain cabins or long-vacant infested cabins.

Lyme disease is the most common vector-borne disease in the U.S. today. Numbers of cases have been increasing nationwide, but the majority of cases occur in the northeast U.S. In California, the adult or sub-adult (nymph) western black-legged tick transmits the Lyme disease agent, *Borrelia burgdorferi*, to humans and risk of acquiring Lyme disease is highly correlated with exposure to *I. pacificus* nymph habitats (Eisen et al *Am. J. Trop. Med. Hyg.*, 75(4), 2006, pp. 669–676.) *Ixodes pacificus* ticks are infected at a lower prevalence than their eastern counterparts (nymphs typically 0-15% and adults typically 0-2%) and thus fewer human cases are reported in California each year - about 100 per year since 1995 (CDPH). *Ixodes pacificus* ticks are found in patchy distribution patterns in moist, humid environments, such as in coastal redwood or hardwood forests. The tick feeds on small mammals, lizards and, as an adult, on larger mammals such as deer. Depending on the habitat type, the reservoir for *B. burgdorferi* from which the tick acquires the infection, can be small mammals such as the deer mouse, woodrat or western tree squirrel (Brown et al J. Med. Entomol. 43(4): 743-751 (2006)). Exposure to the western black-legged tick in California is most often through recreation or occupation when people go into areas where ticks are prevalent; peridomestic exposure may also occur, as increasing development in previously wild areas continues. Climate change may impact the distribution of the vector tick as wet, humid areas become drier and less suitable as *Ixodes pacificus* habitat while other areas may become wetter, allowing for the vector tick to exist where it previously did not. Abundance of small mammal reservoirs may similarly be affected as described for hantavirus above.

California had a total of 380 West Nile virus (WNV) human symptomatic cases in 2007, compared to 278 in 2006 and 880 in 2005 (CDPH, 2008). Like the related Saint Louis encephalitis virus (SLE), also endemic to California, WNV development within the mosquito increases as a linear function of temperature, when temperatures are above 14.7^{o} C. [Reeves et al., J. Med Entomol. 3193: 323-332 (1994)]. Above average summer temperatures in California and other temperate regions of the United States are related to WNV epidemic conditions (Reisen, 2006, Epstein PR. 2001.West Nile virus and the climate. *J. Urban. Health* 78:367–71). SLE and perhaps WNV activity appears to be greatest during La Niña conditions of drought and hot summer temperatures. Though increased rainfall may temporarily provide increased mosquito breeding sites, in fact, rainfall has little effect on SLE or WNV transmission since urban mosquitoes breeding in municipal water systems may benefit from below-normal rainfall. The 2006-2008 WNV seasons saw drier rural areas than in previous years, and an abundance of urban mosquito breeding sites augmented by unmaintained swimming pools in foreclosed homes, resulting in more intense urban WNV transmission than in previous years (Vector-Borne Disease Section 2007 Annual Report www.cdph.ca.gov/programs/vbds/pages/vbdsannualreports.aspx). In the California Mosquito-borne Virus Surveillance and Response Plan (www.westnile.ca.gov), average daily temperature in the previous half month is used prospectively to forecast risk during the coming season.

- The Food Supply

Marine Biotoxins: Warming oceans and rising sea level may have a dramatic impact on both commercial and recreational shellfish harvesting. Increased water temperatures could lead to an increase in the frequency and distribution of naturally-occurring pathogens such as *Vibrio parahaemolyticus*, which has caused hundreds of illnesses linked to shellfish consumption. Likewise, increased temperatures, combined with decreased salinity from greater rainfall, could result in increases of the deadly *V. vulnificus* bacterium currently found predominantly in the Gulf of Mexico.

Exceptionally clean water is necessary to ensure that filter feeding shellfish are safe for consumption. Rising sea level will inundate coastal structures, flooding septic systems and other low-lying sewage collection systems. As a result, coastal waters, particularly in bays and estuaries, will be too polluted for shellfish culture, harvesting and consumption.

Marine biotoxins are naturally occurring neurotoxins produced by a small number of single-celled marine algae called phytoplankton. Phytoplankton populations are affected by a variety of physical processes (e.g., sea surface temperature, upwelling, nutrient flux, salinity) that could dramatically change due to global warming. Marine toxins are bioconcentrated by filter-feeding organisms such as bivalve shellfish (e.g., mussels, clams, oysters, scallops), omnivorous crustaceans (e.g., Dungeness crab, lobster), and small finfish (e.g., anchovy, sardines). The occurrence of these toxins in seafood presents serious health risks to human consumers as well as marine life such as sea lions and sea otters. Globally there are regions with a long history of illness outbreaks associated with one or more of these toxins. For example, California has had illnesses and deaths associated with the paralytic shellfish poisoning (PSP) toxins documented in coastal tribes predating written history. Likewise there have been regions with no prior history of marine biotoxin activity. Some of these unaffected regions have fairly recently begun experiencing illness outbreaks associated with marine toxins. For example, an outbreak in the Philippines in 1983 due to the PSP toxins resulted in 21 deaths. In 1987 there were 26 deaths in Guatemala due to a PSP event. In Canada there were 4 deaths and hundreds of illnesses in 1987 due to a new toxin called domoic acid, which produces a syndrome called Amnesic Shellfish Poisoning (ASP). This was the first known occurrence of this toxin anywhere in the world. Four years later this toxin was identified in California, where it caused hundreds of deaths in marine birds in Monterey Bay. Fortunately no human illnesses were recorded during that event.

Crop yields: Climate change could present serious negative impacts to the crop yields of California's agricultural system, including both annual and perennial crops. Not only is the food produced in California necessary to feed Californians, especially fresh fruits and vegetables that are a critical part of a healthy diet, but many of the crops are produced for export outside of the state and to other countries, and result in significant tourism (e.g., wine grapes). Any significant decrease in crop yields endangers food availability to Californians, the multibillion agricultural system, and also the employment of many low-paid migrant farm workers.

Fisheries: Changes in ocean conditions will also substantially change the distribution and abundance of major fish stocks. Impacts to fisheries related to El Nino/ Southern Oscillation illustrate how climate directly impacts marine fisheries on short term scales. Higher sea surface temperatures in 1997-1998 during the El Nino had a great impact on market squid, California's largest fishery by volume. The California Regional Assessment reports that landings fell to less than 1,000 metric tons in that season, down from 110,000 tons in the 1996-1997 season. Other unusual events also occurred such as poor salmon returns, a series of plankton blooms, and seabird die-offs. As with agricultural crop yields, significant declines in fisheries will adversely affect the availability and price of fish (an important component of a healthy diet) and employment of workers in this industry.

Additionally, food systems may be under stress due to disruptions in transportation systems (e.g. extreme weather conditions, heat buckling of roads or railways).

Health inequities: Declines in crop yields and fisheries may contribute to substantial increases in food prices, which would disproportionately impact low income communities who already spend a higher percentage of their income on food.

- Mental Health

According to the World Health Organization, mental health problems are likely to increase significantly by 2020 and by 2050 will be the second leading cause of illness, after heart disease, if present trends continue. Mental health is greatly influenced by external, societal, and climate factors. Climate events are linked to increases in anxiety, depression, alcohol and other drugs, domestic violence, and suicide. Additionally, there are three broad categories of mental health climate change related impacts, which have both immediate and long term effects, including those conditions:

1. Following extreme events. There is considerable evidence that the greater the extent of the individual's exposure to the catastrophic event, the worse the mental health consequences. Additionally, the existence of pre-existing mental health conditions and other health problems increases the risks of post event mental illness. Following Hurricane Katrina, nearly half of New Orleans residents suffered from depression, panic disorders, and post-traumatic stress.
2. Resulting from economic, physical, and infrastructure shift or relocation. A current example of these effects is seen in communities experiencing a severe, enduring drought in Western Australia. Farm communities are experiencing increased suicides and mental illness rates that are more than double the rates of non-drought farm communities.
3. Emerging from growing awareness of the global threat posed by climate change, especially among youth. Reports and surveys of youth reveal increased anxiety about climate change and its impact on the future. http://www.cdc.gov/climatechange/effects/mentalhealth.htm

Health inequities: Low income communities may experience greater stress due to their more limited ability to withstand economic dislocation, including lower probality of being insured for damage to homes and other property losses.

Public Health Adaptation Strategies

In this section, we present overarching strategies to minimize the actual human health impacts of the risks and vulnerabilities identified in the prior section. Future drafts will provide additional specificity under each overarching strategy.

Overarching Strategy #1: Promote community resilience to reduce vulnerability to climate change.

Multiple strategies are needed to help communities build resistance to and resiliency against the impacts of climate change. These strategies will require cross-disciplinary approaches that incorporate public health, health care, land use, transit, agriculture, and other sectors of the state's infrastructure, in addition to traditional community-based structures of support including families, neighbors, and voluntary organizations. The most critical strategies will achieve the following:

- *Promote built environments that mitigate climate change and/or reduce the impact of climate change on health*:

  Built environment and health: Community design, land use and transportation, and buildings – the built environment – have a very significant impact on community health, including obesity and chronic illnesses such as asthma and cardiovascular disease. The greatest burden of these conditions is falling on the most vulnerable segments of the community, those already challenged by poverty, low educational attainment, and other inequities.

Many of the strategies to improve public health through changes in the built environment are the same as strategies to mitigate greenhouse gas emissions.

- Increase urban residential density and land use mix
- Increase road connectivity and bike/walk infrastructure to promote walking and cycling
- Increase public transit
- Increase open space and parks
- Enhance streetscape design to improve aesthetics and safety for pedestrians and cyclists (e.g. street trees)
- Improve access to healthy foods through school and community gardens and support of local food systems (e.g. farmers' markets, farm to school/farm to community)

Prioritization of strategies with climate change and public health co-can improve public health and build resiliency and capacity to respond to climate change.

Building Resilience
Additional strategies having multiple co-benefits are needed to build the resilience and capacity of the most vulnerable segments of the community, especially children, disabled and seniors. These strategies could also contribute to further reductions of greenhouse gas emissions.

- Conduct community wide assessments to identify the homes occupied by disabled persons and seniors; assess the safety, energy and water use efficiency of these homes, and modify or retrofit homes, if needed. Modifications could include installing: access/mobility enhancing features and other physical safety improvements (e.g., smoke alarms and walkway lighting); weatherproofing; energy efficient appliances; shade cover including planting trees.
- Identify "heat island" areas of community and increase ground cover and shade by creating or expanding urban forests, community gardens, parks, and native vegetation-covered, open spaces.
- Increase access to air conditioning, particularly in areas where it is currently not common and in population groups that lack access. Consider expanding existing programs that help low income people pay for residential heating to include residential cooling as well. (note that air conditioning use may increase greenhouse gas emissions and health problems related to fossil fuel combustion)
- Expand "safe routes to school" and "green tools for schools" to promote increased physical activity, enhance school performance, and improve health and safety of children in and around school.

References
Dr. Lawrence D. Frank, Dr. Kim Raine, University of Alberta; Creating a Healthier Built Environment in British Columbia, A Summary Report for Provincial

Health Services Authority's Prevention, Promotion and Protection Program, September 2007.

AB 32 Scoping Plan, California Air Resource Plan, Adopted December 2008.

Younger M, Morrow-Almeida HR, Vindigni SM, Dannenberg AL, The built environment, climate change, and health: opportunities for co-benefits; Am J Prev Med; 2008-Nov; vol 35 (issue 5) : pp 517-26.

Wildfires: Many aspects of the built environment may serve to reduce the impact of climate change on human health. For example, recommendations to reduce the risk of structures burning in wildfires include: minimum brush clearance requirements, use of fire-resistant landscaping and fire resistant of non-combustible materials for roofs and exteriors, clear areas around propane tanks, proper storage of flammable materials, and (in fire-prone areas) maintenance of an outdoor water supply such as a pool or pond.
http://bepreparedcalifornia.ca.gov/EPO/BeInformed/NaturalDisasters/Wildfires/About+Wildfires.htm

Encourage individuals and families to have an evacuation plan in the event of wildfire, keeping in mind that a wildfire may disrupt usual travel routes. These plans should include provisions for sheltering in place if not directed by authorities to evacuate, and should include planning for food and especially water in the event that utility service is disrupted by the fire.

Urban heat islands: There are many actions that cities can take to address the urban heat island problem. Parks, street trees, and green roofs help reduce surface temperatures in cities while also creating more walkable, liveable communities. Trees provide cooling shade, and can significantly reduce home energy costs. In addition, vegetation helps to improve local air quality (Taha et al, 1997). A recent study also suggests that planting four urban shade trees reduces annual carbon emissions by 9,000-41,000 tons per year (Akbari 2002). Building roofing occupies about 19% of the area of a city. Cool roofs use light-colored roofing materials that reflect heat rather than absorbing it. Green roofs use living vegetation to reduce heat. Although green roofs are currently expensive (approximately $12-25 per square foot), cool roofs are cost-effective at less than $2 per square foot. Cool pavements include the use of more reflective light-colored materials instead of black asphalt, as well as the use of permeable pavements. These strategies have additional benefits such as improved nighttime visibility allowing a 30 percent savings in street lighting.

Cooling urban heat islands will have only modest costs, outweighed by major benefits in California. Better yet, this adaptation strategy will provide ancillary benefits for climate change mitigation, public health, and the environment.

References:
Akbari H. Shade trees reduce building energy use and CO_2 emissions from power plants. Environ Pollution 116(S1):S119-126, 2002.

Lawrence Berkeley Labs Urban Heat Island Group. http://eetd.lbl.gov/HeatIsland/.

Taha H. Modeling the impacts of large-scale albedo changes on ozone air quality in the south coast air basin. Atmospheric Environ 31(11):1667-1676, 1997.

Sustainable South Bronx. Urban Heat Island Mitigation Can Improve New York City's Environment. Working Paper, October 2008. http://www.ssbx.org/RECENTPUBLICATIONS.htm.

http://www.urbanheatislands.com/

Water: The use of permeable surfaces (e.g., in parking lots or roads) reduces storm water runoff, thus reducing the risk of flooding and pollution outflows (which increase risk of harmful algal blooms), and increase recharging of ground aquifers. Land use planning and management practices can also minimize soil erosion that may increase flooding risks.

Evaluate the capacity of statewide water and sewage treatment facilities, and modernize and expand these facilities as necessary to meet predicted worst case precipitation scenarios. Replace remaining combined sewage systems in the State with modern systems.

Graywater: SB 1258, recently signed by the governor, directs the Building Standards Commission (BSC) to adopt changes (by 2011) to the plumbing code to address graywater installations. The California Water Code defines graywater as, "untreated wastewater which has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and which does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. Graywater includes wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs but does not include wastewater from kitchen sinks or dishwashers."

Expanded graywater use should ensure protection from bacteriologic and other contamination; in particular, building standards provisions should be included to prevent possible backflow from a graywater system into a domestic drinking water supply.

Desalination: Salinity reduction treatment or intake relocation will probably be necessary to address the deterioration in water quality .Desalination of seawater requires reverse osmosis membranes to remove the salt and other contaminants. which means expensive capital and high operational costs due to high energy requirements. Treatment for salinity reduction generates a highly concentrated waste stream of brine that is very difficult to dispose of in an environmentally acceptable, cost-effective manner; seawater desalination also risks fish entrainment and has significant implications for energy use and greenhouse gas emissions. Problems with salinity and brominated disinfection byproducts already exist in the water supply for the State Water Project, which is diverted from the Sacramento Delta near Tracy and is used by over 20 million Californians as a source of drinking water. These problems will be exacerbated by both rising sea levels and wider fluctuations in river flow caused by other effects of climate change (e.g., a much smaller snowpack). . The costs associated with these projects will be enormous.

- Reduce toxic air pollution to reduce baseline exposures to toxins (e.g. ozone and particulate matters) that will increase with climate change, including through such measures:

  - Maintaining strict regulation of air pollutants will be an important support to community resilience. Some pollutant levels will be altered by changing temperatures and locations. Furthermore, some of the regulated air pollutants may act as green house gases and therefore require more stringent regulation. New controls for green house gases that are not presently regulated as pollutants will be required.
  - Initiatives like the California Green Chemistry Initiative that support reduced use of toxic materials and use of alternatives that maintain product performance but reduce environmental and health effects will be central to any strategy to build community resilience.
  - Increasing community bike/walkability and expanding public transit – measures that will also improve health through increased physical activity and possibly reduced injury rates.
  - Reducing exposures to combustion products (e.g. through actions such as CARB regulations on diesel trucks, increased car fuel efficiency, etc.)
  - Promote sustainable local food systems: a sustainable food system provides healthy, accessible, and affordable food while maintaining healthy ecosystems with minimal negative impact on the environment. http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1361 Local food systems help reduce the length of the supply chain between producer and consumer, as well as the amount of inputs needed to produce food, including fertilizers, transportation, and storage, all of which should help reduce costs. From an emissions perspective, food miles make up a very significant proportion of all vehicular transport which also contribute to congestion, demand for new roadways, and fuel consumption.
  - Consider climate change as part of planning efforts directed at attaining the health based ambient air quality standards.
  - Review and, as appropriate, revise occupational health and safety standards to identify occupations at risk due to climate change or climate mitigation and adaptation strategies: for example, agricultural and construction workers exposed to heat, solar installation workers at high risk of falls (similar to roofers), forest fire fighters, solar panel manufacturing workers, etc.

- Strengthen the health infrastructure:

  - Promote increased access to health care, to ensure adequate access for individuals who suffer health consequences related to climate change
  - Ensure that health care providers are educated about climate change and health impacts thereof, including diagnosis and treatment of climate-related illness and recognition of emerging trends.

- Review and expand existing vector control programs as necessary.

- Promote strong social support networks

  - Develop integrated and comprehensive approaches to respond to economic and physical dislocations and shifts that provide supports and structures to either mitigate the impacts of these shifts or stabilize neighborhoods and communities as quickly as possible after dislocations.
  - Develop climate change communication tools, techniques, and messages that promote active public and individual discourse, engagement, and positive actions.
  - Expand training and education of health and social services systems/providers to identify and treat mental health problems and integrate mental health into systems and services deployed post disaster and in the wake of economic and other dislocating or disruptive climate related changes.

Overarching Strategy #2: Educate, empower, and engage California citizens and organizations including businesses to take actions to reduce individual and community vulnerability to climate changes through both mitigation and adaptation.

Preventing, preparing, and responding to climate change not only lies in the hands of government, but also in the hands of California residents and its numerous non-governmental organizations and businesses. Individuals and businesses have shown great capacity to implement practices that have reduced water, electricity, and fuel consumption. The 37 million residents of California can do even more if provided with the appropriate information and means to make real changes that can help reduce the impacts of climate change in their households and in their communities. Education about the health impacts of climate change can be a motivator for action to prevent dangerous climate change. Effective public health communication that educates people about opportunities for action rather than simply causing stress, fear, and despair may also foster more support for mitigation strategies, and reduce the mental health burdens of climate change anxiety. Outreach to and engagement of individuals and organizations across many sectors and all aspects of communities will be necessary to prepare for climate change.

Strategies to further engage Californians in climate change activity include:

a. Urgently expand dissemination of climate change health impact information including impacts, co-benefits of mitigation strategies, and preparedness strategies
   1. Engage vulnerable communities and at-risk populations
   2. Outreach to clinicians and health sector
   3. Outreach to businesses and private sector
   4. Outreach to tribal nations
   5. Improve coordination of health-risk communication strategies and integrate climate change in other efforts (e.g. PH preparedness)

b. Disseminate information to address specific risks associated with climate change (e.g. to prevent heat illness in communities and in workplaces, vector borne, or food-borne disease, etc.)

c. Disseminate information specific to vulnerable populations (e.g., outdoor workers and residents in urban heat islands or people with chronic illness regarding heat, immigrants with literacy/language needs)
d. Identify specific groups at risk for heat-related illness, including the elderly and outdoor workers (farm workers, construction)
e. Educational materials should be available in multiple languages to reach wider audiences.
f. Formally engage the full community in planning and preparing for an effective disaster responses, as well as climate change mitigation and adaptation. It is especially critical that efforts are made to engage the most vulnerable segments of the community in this planning. This could help to fortify community mental health in advance of a disaster or the changes required for mitigation or adaptation.

Overarching Strategy #3: Identify and promote mitigation and adaptation strategies with public health co-benefits:

It is critical to document that mitigation and adaptation strategies can have "value-added" impacts for the public's health. Strategies with co-benefits should be prioritized, particularly in light of limited resources available both for climate change mitigation/adaptation and for public health prevention. When possible, adaptation strategies that increase health risks and/or greenhouse gas emissions should be avoided (e.g. promoting air conditioner use without changes in electricity production reliance on fossil fuel combustion). Strategies to optimize public health co-benefits include:

a. Conduct health assessments of proposed mitigation and adaptation strategies, including impacts on vulnerable populations and communities and assessment of cumulative health impacts; conduct health assessments of land use and transportation proposals that could impact health, greenhouse gas emissions, and community resilience for climate change.
b. Ensure public health participation in and preparation for discussions about proposed mitigation and adaptation strategies and in land use and transportation planning processes (e.g. SB 375 and Blueprint)

Overarching Strategy #4: Establish, improve, and maintain mechanisms for robust rapid surveillance of environmental conditions, climate-related illness, vulnerabilities, protective factors, and adaptive capacities.

Surveillance capacity is a key aspect of public health preparedness and response. Surveillance in relation to climate change involves the collection and analysis of health outcomes, environmental conditions, population vulnerabilities, and mitigation, adaptation, and policy measures. With timely surveillance data, trends in selected indicators can be scrutinized for prediction of future threats and resource needs, which are important inputs for health planning. Also, these data are important for identifying vulnerable populations who are at most risk of impacts. Surveillance of climate change impacts needs to occur both at the state and local levels. For example, vector-borne disease surveillance can be centralized at the State level, but data on local adaptation approaches such as making buildings energy efficient and measuring indices of walkability may be more easily collected at a local level.

Surveillance related to heat morbidity and mortality in California depends on several elements: (1) heat alerts/warnings issued by the National Weather Service (NWS); (2) heat wave warning systems; (3) heat wave preparedness plans; and (4) surveillance programs and data sources.

The NWS issues heat warnings and alerts, which trigger the governor's emergency response system (Office of Emergency Services) and the opening of cooling centers. However, the criteria used to heat warnings and alerts are not based on public health thresholds for morbidity or mortality, nor are they adjusted for regional adaptive capacity.

There are few emergency heat warning systems in the U.S. Notable exceptions are systems in Philadelphia and Chicago. Heat warning systems can save lives. For example, an evaluation of the Philadelphia system found 2.6 lives saved for each warning day and for the 3 days after the warning ended. Overall, the system saved an estimated 117 lives over a 3-year period (Ebi et al., 2004). Integrated with proper response, emergency heat warning systems can reduce population vulnerabilities, increase resilience to future extreme events, and help identify vulnerable populations (Ebi and Schmeir, 2005).

The primary programs in California which are related to heat surveillance are the California Electronic Death Registration System (CA-EDRS), the State Center for Health Statistics, the Office of Statewide Health Planning and Development (OSHPD), the CDPH Emergency Preparedness Office, the CDPH Division of Chronic Disease Epidemiology and Injury Control (EPIC) Branch and the CDPH Division of Environmental and Occupational Disease Control. CA-EDRS is not currently set up to do rapid real-time surveillance of heat deaths, but could be augmented with additional programming to accommodate additional input from coroners on heat deaths. Data from death certificates from the Center for Health Statistics to compute numbers of heat deaths and excess mortality statistics currently experiences a two-year lag. CDPH capacity to conduct analysis of coroner-certified deaths related to heat illness is very limited. Data on heat morbidity (hospitalizations and emergency room visits) from OHSPD also experience a two-year lag until availability for analysis. More real-time surveillance could come from BioSense hospitals (a hospital surveillance program funded by the CDC); however there is not currently statewide coverage (see below).

<u>Identification and tracking of health conditions that increase vulnerability to climate-related illness and deaths (e.g., chronic diseases)</u>

Co-morbidity and risk factor data is available for counties and county clusters from the California Health Interview Survey or the California Behavioral Risk Factor System. For specific climate-related outcomes, other sources of geographic data can be added to survey data to conduct local or regional vulnerability analysis. For example, Reid et al. (2008) used BRFS data for co-morbidities, U.S. Housing Survey data for air conditioner use and land cover, and U.S. Census data to map vulnerabilities for heat illness in the U.S. Additional data could be added, for example coverage by impermeable surfaces or tree coverage. A vulnerability assessment for heat-related illness and mortality has been completed for California (http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf).

Real-time electronic tracking of climate-related illness and deaths

California is moving from a paper-based disease surveillance system to electronic communicable disease and lab reporting (Web-CMR and Electronic Lab Reporting). Although these new systems will bring about more rapid identification of disease outbreaks, they are not real-time surveillance systems. Besides Department of Defense facilities and VA clinics, the only areas in California with real time surveillance data are San Diego and Los Angeles counties and one hospital in Lassen County (hospital data from the CDC BioSense program).

CDC is exploring ways to develop rapid surveillance by coordinating with larger entities such as the Regional Health information Organizations (RHIOs) and Health Information Exchanges (HIE). All California emergency rooms could be connected to a statewide HIE, as has been done in Pennsylvania (the University of Pittsburgh Real Time Outbreak Detection System) or in North Carolina (NC DETECT).

Post-Disaster Surveillance

Post-Disaster Surveillance is coordinated by the Emergency Preparedness Office and the Emergency Preparedness Planning (EPP) Team in DEODC, using tools such as the Rapid Response Registry (RRR). The Rapid Response Registry (RRR) was created by CDC to enroll all people who were exposed or potentially exposed to an emergency event with the primary purpose of obtaining contact information to facilitate the provision of health information and services. DEODC created a slightly modified version of the RRR Survey Form. In addition, the DEODC RRR Survey Form has been translated into three languages: Spanish, Chinese, and Vietnamese. The DEODC RRR Survey Form (and translated forms), the Interviewer Training Module, and Access database for data entry are all on the CA Health Alert Network (CAHAN). The EPP Team coordinates DEODC's on-call duty officer system, which provides assistance on epidemiologic, medical, toxicological, and other issues that may be relevant to surveillance and response. Real-time surveillance – for example through the use of CDC-developed Rapid Epidemiological Assessment Survey methodology – is also critical in ascertaining community needs (for water, medical care, housing) after a disaster event.
There is also a need to build capacity for surveillance of risks and protective factors in the built environment, as well as community vulnerability factors such as social support, food access, availability of cooling centers, etc.

Tracking of environmental conditions that provide early warning systems of climate-related health risks

The Vector-Borne Disease Section of the Infectious Diseases Branch of the Division of Communicable Disease Control in CDPH conducts prevention, surveillance, and control of vector-borne diseases, including hantavirus cardiopulmonary syndrome, Lyme disease, West Nile virus infection and other tick-borne and mosquito-borne diseases. The Office of Drinking Water is migrating to a new electronic system in 2009, the Safe Drinking Water Information System (SDWIS). Currently, there exists no centralized source of drinking water system boundary files, so it is impossible to identify the source of drinking water contaminants based on an individual's address in a timely manner. The California Environmental Health Tracking Program is currently working with the Office of Drinking Water to develop a comprehensive set of electronic drinking water system boundaries, in cooperative with the water providers.

Wildfires

The National Weather Service provides fire weather forecasts for California through its red flag warning system (http://www.wrh.noaa.gov/sto/cafw/fwfall.php?wfo=sto) The Fire and Resource Assessment (FRAP) Program of the California Department of Forestry provides several products and services for response and preparation for wildfires, including mapping of communities at risk from wildfire (figure), fire hazard severity zones, and wildland fire threat (based on potential fire behavior and expected frequency).

San Diego State University have developed a pilot system which analyzes the spatial and temporal patterns of 911 calls in California to direct early resources and response to California wildfires (http://www.sciencedaily.com/releases/2008/02/080213133301.htm). Remote solar-powered sensors are also being piloted to give warnings of early wildfire spread (http://www.voanews.com/english/archive/2005-06/2005-06-29-voa33.cfm). NOAA and USGS have also developed a demonstration project of an early warning system for identifying areas at risk for flash floods after wildfires (http://www.wrh.noaa.gov/lox/main.php?suite=hydrology&page=debris-flow_project) The Forest Service, in partnership with the Department of Interior, maintains real-time particulate smoke monitoring from remote sensors (http://www.satguard.com/USFS4/default.asp).

Primary adaptation activities from CDPH for wildfires are to provide information about sheltering in place and other procedures for the public to follow if they are affected by wildfire smoke, and other preparedness measures, including home fire prevention and water supply (http://bepreparedcalifornia.ca.gov/EPO/BeInformed/NaturalDisasters/Wildfires/About+Wildfires.htm).

New systems for real-time and syndromic surveillance on a state-wide level are unlikely to be developed from scratch, because of the cost involved. Here we consider examples of two existing systems that could serve as the basis for building better real time surveillance for climate-related illness: the California Electronic Death Reporting System (EDRS) and the Kaiser patient record systems.

In California, death certificate information is reported to the state Office of Vital Records via a web-based system, (EDRS). Certificate information on expected and medically attended deaths comes from physicians and funeral directors. Coroners and medical examiners (C/MEs) report deaths that are unexpected or medically unattended, including all injuries. Within 48 hours of a death, initial information is entered into the EDRS web site on a server in Sacramento.

Along with the pages in which death certificate information is entered, it is possible to build special pages for gathering extra data. Because the pages are controlled centrally, pages could appear for selected counties, victim characteristics, or cause of death. Special pages could be developed in advance to be implemented when and where necessary. As special information is reported, it can be tabulated and analyzed. When an event changes, special pages can be changed in response. This system would provide very current data for monitoring events in progress.

EDRS could also be used for continuous monitoring of anomalous death patterns, for example a rise in deaths to young women, Asians, or residents of Sierra counties. Patterns of cause of death, such as upticks in "undetermined", pneumonia, or asthma, could similarly be monitored. This syndromic use of EDRS would be largely automatic, since human operators would mainly watch for anomalies that appear in profile summaries.

Kaiser hospitals use a real-time system to manage all their patient records. Kaiser has 31 hospitals in California, with good coverage of southern California, the Bay Area, and the San Joaquin Valley up to Sacramento. It would be possible to use such a system for daily monitoring of emergencies simply by monitoring daily data hospitalizations, emergency department care, including diagnostic, laboratory, and prescription information. Special tabulation and analysis of such information could be done for the duration of an emergency.

Indicators from a statewide and local level can be paired to inform local or regional analyses, such as what is being done in the Austin Climate Protection Program. Indicators such as the number of households living within a specified radius of coal-fired power plants or busy roads, miles of bike paths, and greenhouse gas emissions per capita are being developed that can be tracked along with health outcome measures to measure local impacts on health from mitigation or adaptation measures.

Surveillance of resilience factors and psycho-social impacts

Individual and community resiliency and social support are likely to influence the manner and extent to which communities adapt to the stress of extreme weather events or other climate change impacts, and their ability to avoid repercussions such as depression and post-traumatic stress disorder. Information on individuals could be obtained from specific questions added to the California Health Interview Survey or the Behavioral Risk Factor Survey. Other surveys, such as those which could be conducted by the Public Policy Institute of California or Associations of Governments, could quantify the social capital of communities, including the number of shelters, aid and relief organizations, and other community agencies.

Recommendations

- California must reinforce its health surveillance capacity and move rapidly to real-time surveillance of health conditions related to climate change, including heat morbidity and mortality.
- CDPH and NWS should develop regional definitions for heat alerts/warnings which are based on public health thresholds for heat morbidity.
- California should conduct a needs assessment and cost-benefit analysis of implementing an emergency heat warning system.
- California should further develop CA-EDRS to be able to conduct real-time surveillance and reporting of deaths and collect supplemental information from coroners and explore partnering with the Kaiser system for syndromic surveillance opportunities.
- Strengthen surveillance for temperature-related mortality and adverse health effects of air pollution exposure and wildfires, as well as infectious diseases related to water, vector, and food borne pathogens.
- CDC BioSense hospitals should be expanded in California for collection of real-time data.
- All California emergency rooms could be connected to a statewide HIE, such as been done in Pennsylvania (the University of Pittsburgh Real Time Outbreak Detection System) or in North Carolina (NC DETECT).

REFERENCES

Bedsworth, L. Climate Change and California's Public Health Institutions. Public Policy Institute of California, 2008.

Ebi KL, Teisberg TJ, Kalkstein LS, et al. Heat watch/warning systems save lives: estimated costs and benefits for Philadelphia 1995–98. Bull Am Meteorol Soc 2004;85:1067–73

Ebi KL, Schmier JK. A stitch in time: improving public health early warning systems for extreme weather events. Epidemiol Rev. 2005;27:115-21.

Health Canada. Human Health in a Changing Climate. A Canadian Assessment of Vulnerabilities and Adaptive Capacity. Ministry of Health. 2008

Reid CE, O'Neill MS, Gronlund C, Brines, SJ, Diez-Roux A, Brown D, Schwartz J, Zanobetti A. 2008. Mapping community determinants of heat vulnerability. Presented at the 2008 International Society of Environmental Epidemiology Meeting, Pasadena, CA.

Overarching Strategy #5: Improve public health preparedness and emergency response.

California has a long history of addressing catastrophic emergencies, including wildfires, earthquakes, and floods, and also in being prepared for other public health epidemics such as vector borne disease and responding to bacterial outbreaks in our food supply. It is critical that this existing infrastructure of preparedness and response be strengthened and expanded to address preparedness for climate change. Strategies include:

a) Conduct more detailed and locally scaled-down vulnerability assessments for all climate related emergency scenarios
b) Formally request the U.S. Department of Homeland Security and the Centers for Disease Control and Prevention to incorporate climate change response in contracts to state agencies and allow use of Federal public health preparedness funding for climate preparedness.
    1. Incorporate climate change response in contracts between the State Emergency Preparedness Office and local health departments; allow counties to deploy staff time in emergency preparedness toward climate-related emergencies
c) Refine existing preparedness plans for common scenarios (e.g., heat waves, wildfires, vector-borne disease), and ensure that local communities are prepared for the likely expansion in geographic occurrence of some scenarios (e.g. more severe heat events in coastal areas)
d) Create new preparedness plans for scenarios that are not currently planned for (e.g., major flooding, saline intrusion into drinking water supplies, drought)
e) Conduct exercises specifically related to climate impacts (e.g., no drinking water for southern California, major flood or storm surge, etc.)
f) Improve education of the public (this includes community groups and members, workers, and businesses)
g) Work cross-sector with health and emergency preparedness entities to identify and refine scenarios
h) Conduct detailed vulnerability assessments for all the leading climate-change health outcomes.
i) Improve coordination among alert systems and emergency personnel responding to public health emergencies related to temperature, air pollution, infectious diseases, and wildfires.
j) Develop Health Heat Watch Warning Systems for regions of the State that have not yet adopted them. To date, only the San Jose area has a Health Heat Watch Warning System in place. These systems should be coupled with community level programs to provide outreach and services to people in need of cooling centers and other assistance to prevent heat related illness or death. These programs should focus primarily on the elderly and infirm but should not overlook the economically disadvantaged. A recent survey completed by the Public Policy Institute of California found that of 34 local health jurisdictions which completed surveys, 30 had a heat emergency plan in place (Bedworth, 2008). The State of California has developed a statewide Heat Emergency Response Plan http://www.oes.ca.gov/WebPage/oeswebsite.nsf/ClientOESFileLibrary/Plans%20and%20Publications/$file/HeatContingencyPlan.pdf

Overarching Strategy #6: Work in partnership with other agencies (e.g., environmental, agricultural, transportation, education) at the local, state, and federal levels, and with businesses, labor, schools, and community-based organizations.

The success of the overall effort in climate change adaptation will not be due to the effectiveness of one single organization's efforts, but because of the constant cooperation and collaboration that must take place between local, state, and federal governments, the business community, tribal nations, schools, colleges, and universities, and the many community-based organizations. Each of these entities has their own mission and goals, but together, we must all work with one common purpose in averting the negative impacts of climate change, in particular, among our most vulnerable populations. Groups that should be pursued include the following:

a. Organizations who work with vulnerable populations
    1. First Five, aging, mental health, homeless advocates, EJ
b. Local planning and transportation groups
c. California Department of Education and schools
d. The health care sector, including the California Medical Association, the California Nurses Association, the California Hospital Association, the California Association of Health Plans, and the University of California
e. Businesses
f. Labor unions
g. Foundations

Overarching Strategy #7: Conduct research to enable enhanced promotion/protection of human health in light of climate change:

Climate change research will be essential to understanding mechanisms of climate change impacts, developing new technologies and approaches to mitigate future impacts, changing human behaviors and attitudes, and helping adapt the natural and built environments to these impacts.

Research will be required at the global, national, regional, and local levels to identify specific impacts and effective strategies. The local level will be the site of direct action and therefore climate change models that provide useful local information must be developed.

Climate change research must examine uncertainties and assist policy makers with making the best decisions in light of significant uncertainties. Research on climate change mechanisms as well as research on climate change mitigation impacts will be needed to monitor progress and identify unintended consequences. Timely changes in mitigation strategies that don't work or do harm will be needed.

Multisectoral research collaborations, which include public health in all phases, offer the greatest opportunities to maximize the benefits of limited resources for research.

a. enhance understanding of climate change risks and impacts
b. increase understanding of individual and community factors that promote or impede climate change mitigation and adaptation
    1. Expansion of health impacts assessment for climate change, mitigation and adaptation strategy impacts,
    2. Modeling of health impacts at local/regional level

3. More specific analyses (e.g. heat report) of likely health impacts of climate change, included at local level
4. Better analysis of economic impacts of health impacts and of co-benefits
5. Incorporate analysis of impact on sub-populations and impact of mitigation and adaptation strategies on vulnerable populations

c. Collect more precise information on which communities will experience the greatest heat gain, and the environmental determinants of that gain (e.g., topography, regional climate, built environment).
d. Assess the cumulative impacts on vulnerable communities of climate-change, mitigation and adaptation strategies, and pre-existing risk factors/conditions.
e. More precise information on optimum heat and other warning systems for different regions of the State is needed.
f. Community specific assessments of adaptive capacity (for all populated areas of the State not just large municipalities), including a needs assessment.

Overarching Strategy #8: Implement policy changes at the local, regional, and national level.

Public health approaches that require changes amongst the majority, if not the entire population are best served by enacting institutionalized policies, whether they be from elected bodies, quasi-governmental bodies, or become the accepted practices of businesses and community-based organizations. Public health has experienced the greatest public benefit when interventions have been implemented that benefit the entire population (e.g., clean drinking water, sanitation, immunization, no smoking areas, etc.). Public health strategies for climate change adaptation require the same level of policy change that impacts an entire community, region, and state – policies that become the common accepted practice.

Overarching Strategy #9: Identify and develop resources to maintain adequate funding for implementation of Public Health Climate Adaptation Strategy

Effective public health strategies not only require buy-in from the communities they address, but also financial resources. Establishing consistent and continual resources to maintain the infrastructure, research, surveillance, and convening role are essential in ensuring the long-term success of public health adaptation efforts. Funding could come from the following sources:

a) A proportion of the revenues derived from market mechanisms in AB 32 implementation (e.g. carbon auctions, trade, etc.) should be allocated specifically to public health research and public health adaptation, and to promotion of resilience in, especially, Environmental Justice communities
b) Allocate portion of existing funding (e.g. dept Homeland Security, CDC PHP funding) to climate change

Overarching Strategy #10: Lead by example: Encourage active participation of public health and health organizations in individual, organizational, and institutional efforts to mitigate and adapt to climate change.

The United Kingdom Department of Health Guidance Document: ‘Reducing Our Carbon Footprint Code: A sustainable code for the health sector – for hospitals and communities” provides a good model for this strategy. Its components include:

1. **Take a lead in addressing carbon emissions**
2. **Undertake a carbon audit**
   - Measure the organization’s current carbon footprint
   - Identify practical energy efficiency measures based on audit findings
   - Set a target for reducing carbon emissions
3. **Place energy at the heart of the organization – Save money, increase efficiency**
   - Adjust heating controls, upgrade light fittings, use energy efficient bulbs & switch off computer monitors & lights when not in use
   - Sign energy contracts with 100% renewable energy providers, consider technology to increase renewable energy use – solar, wind turbines
   - Maximize roof, wall and draft insulation in order to reduce fuel use
   - Consider electricity & heat generation through Combined Heat & Power (CHP) installations
4. **Reduce water consumption and flooding**
   - Use tap designs and flushes that minimize water consumption
   - Encourage use of tap water to drink
   - Increase green area to concrete ratio to increase absorption of flood water
5. **Make sustainable transport policies**
   - Promote Travel Plans and transport policy that encourage public or active transport
   - Increase ‘virtual’ meetings & teleconferencing, encourage train use versus flying
   - Maintain vehicles to maximize energy efficiency – check tire pressures and replace existing fleets with more energy efficient models
6. **Ensure sustainable catering and food procurement policies**
   - Promote, where possible, local food procurement and cut down on food miles
   - Provide healthier, fresh, seasonal menus; increase vegetable to meat protein ratio and reduce use of processed foods
   - Recommend the use of green gyms, allotments and city farms
7. **Influence sustainable housing and the built environment**
   - Design sustainable healthcare buildings with green spaces which provide healing views, assist in cooling and in flood run off
   - Promote summer cooling by increasing internal and external shading, plant trees and green the surrounding environment
8. **Develop a carbon neutral waste management policy**
   - Build environmental awareness, recycling and sustainable printing into the workplace environment
   - Implement environmentally friendly waste contracts and procedures
9. **Promote local employment & skills**
   - Boost local recruitment through skills qualifications and “grown your own” workforce
   - Adopt flexible work systems that reduce commuting

Bibliography/Additional References

Gershunov, A. and D. Cayan, 2008: California heat waves: July 2006 and recent history. Journal of Climate, in review.

American Medical Association's Report "Heat-related Illness During Extreme Weather Emergencies," (available at http://www.ama-assn.org/ama/pub/category/13637.html)

American Academy of Family Physicians is a fact sheet "Heat Exhaustion and Heatstroke: What You Should Know" (available at www.aafp.org/afp/20050601/2141ph.html)

Trent, R. Review of July 2006 Heat Wave related Fatalities in California. California Department of Health Services, Epidemiology and Prevention for Injury Control Branch. May 2007. (Report Available at: http://www.cdph.ca.gov/HealthInfo/injviosaf/Documents/ HeatPlanAssessment-EPIC.pdf).

Margolis HG, Gershunov A, Kim T, English P, Trent R. 2006 California Heat Wave High Death Toll: Insights Gained From Coroner's Reports and Meteorological Characteristics of Event. 2008 Conference of International Society of Environmental Epidemiologists, Pasadena, CA (Presented October 15, 2008; Abstract ISEE-1672, November 2008 Supplement to Epidemiology 19(6): S363-364.)

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ. Health Perspectives. August 22, 2008. doi:10.1289/ehp.11594 (http://dx.doi.org/)

California Department of Public Health. Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies. Report No. 1: Heat-Related Illness and Mortality Information for the Public Health Network in California. 2007. (Available at: http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf.)

Ocean and Coastal Resources Climate Adaptation Working Group
(give web link)

Washington State Adaptation Strategy (web)

Alaska State Adaptation strategy http://www.akclimatechange.us

Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity

Adaptation Strategies for Western Australia

McMichae AJ, Kovats RS. Climate change and climate variability: Adaptations to reduce adverse health impacts. *Environmental Monitoring and Assessment* 2000; 61: 49-64