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Theme Paper *Theme VII*

Climate change and water resources planning; a somewhat sceptical view

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Many papers and articles on climate change are published each year; much to the detriment of our carbon-storing forests. Such papers include serious discussions of, for example, the effects of climate change on lawn watering (Environment Canada, 1989). In this literature, climate change is generally assumed to be synonymous with global warming due to anthropogenically-caused incr eases in atmospheric carbon dioxide and is generally assumed to be "a bad thing". This short paper will attempt to show that the situation is not as clear as some authors make out and that some of these assumptions are not correct.

First, let's agree that the overall greenhouse effect is a good thing; without it, the average surface temperature of the earth would be about -18°C (Milch, 1999) and life would be rather uncomfortable.

There is also no argument that human activity has changed the composition of the atmosph re. The build-up of carbon dioxide intensified with coal burning in the industrial revolution and continues today with increasing fossil fuel consumption (IPCC, 1995). Similarly, anthropogenic nitrogen f ixation has doubled in the last twenty years as a result of increased f ertilizer use, fossil fuel combustion and fixation by leguminous crops (Walker and Steffen, 1999). The atmospheric concentration of methane has incr eased at a rate of about 1% per year (Glantz and Krenz, 1992) due mainly to wet-paddy rice farming and livestock farming.

However, the case against humans is not as clear as some make out. First, changes in climate have occured since the earths formation, as a result of permutations of the 105,000; 41,000 and 21,000 year solar obliquity, eccentricity and precession periods (Harrington, 1987). Distinguishing between such longer time-scale effects and the much shorter time-scale changes that we can observe is not simple. Second, carbon dioxide, methane and the CFCs are not the principal greenhouse gasses. Air contains 40,000 ppm water vapour compared to 350ppm carbon dioxide and humans have no control over water vapour emissions. Third, the scale of climate change associated with the anthropogenic greenhouse effect (0.5° C rise in mean annual global temperature since 1860, IPCC, 1995) is small compared to the change of 5° C which has occured over the last 10,000

years (Saltzman, 1983). Fourth, the assertion that high levels of carbon dioxide and high temperatures are necessarily coincident may not be correct. Figure 1 shows that 450 million years ago the CO_2 level was 12 times higher than today and yet the earth was in the middle of an ice age 5° cooler than today (Paterson, 1993).

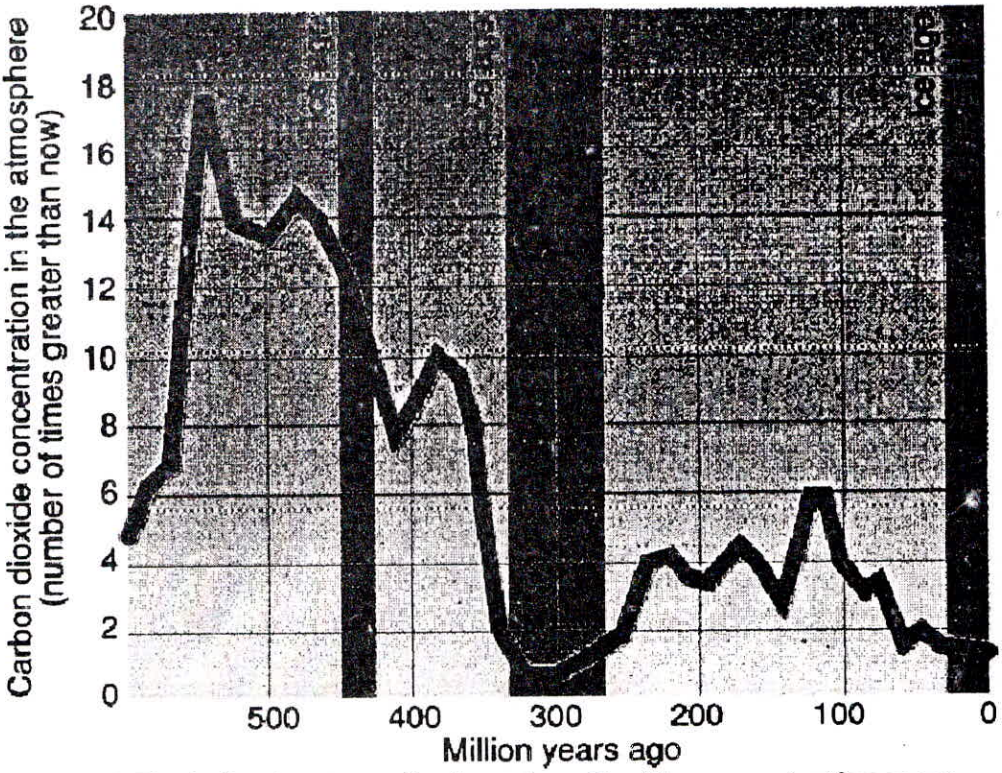

Figure 1. Variation in atmospheric carbon dioxide concentration measured from ice cores.

We have more uncertainty in interpreting more recent climate data. The IPCC (1995) shows graphs of the rise in northern hemisphere temperature over the last hundred years as evidence of global warming but these data are averages of temperature records from many thousands of stations and may hide the true picture. Goodridge (unpublished) has shown (Figure 2, top left) that if data from all climate stations in California are averaged, there is an upward trend in temperature. However, if the stations are divided into urban (top right) and rural stations (bottom left), we see two different trends. The cause of the strong upward trend in urban stations is clear; cities are islands heated by airplane and car exhausts and by the heating and cooling of buildings. The cause of the rural decrease in temperature is not so clear. Could it be that global temperatures are really decreasing and that the urban areas are anomalies? We don't know; climate stations are sited where there are people to service them.

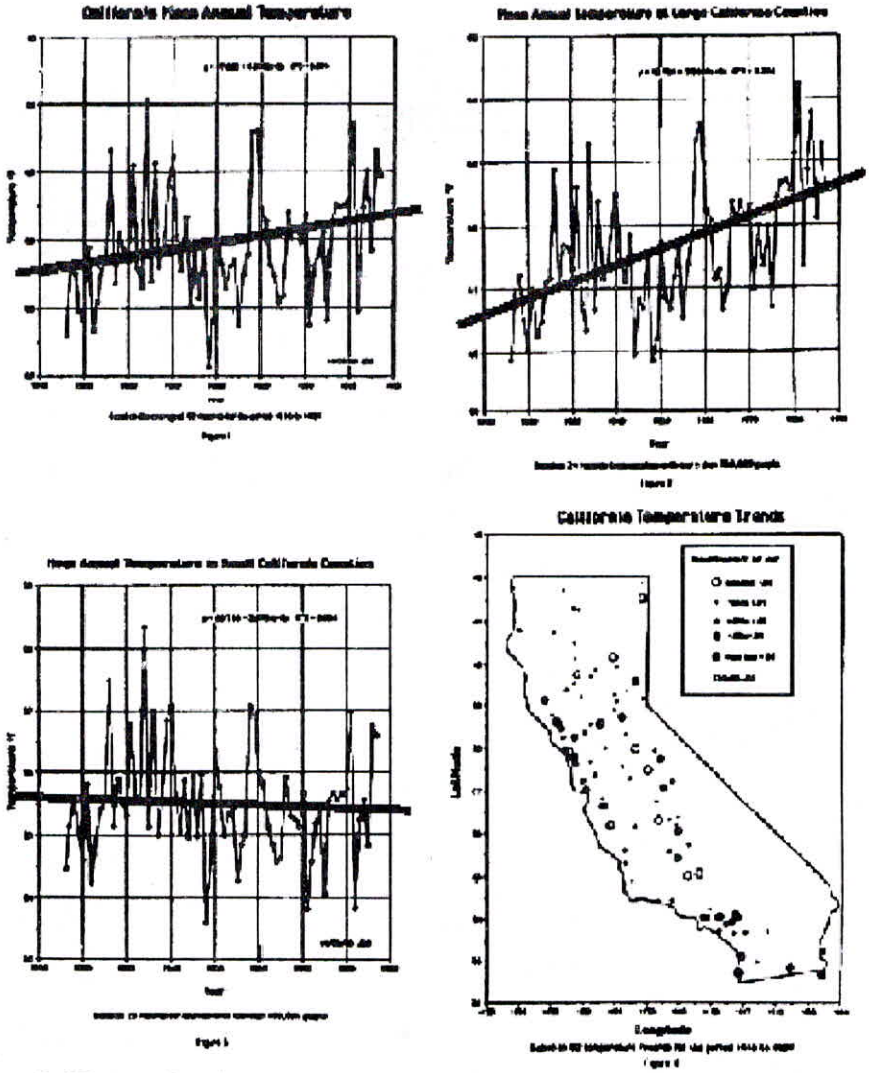

Figure 2. Upward urban and downward rural temperature changes, California.

Future climates are predicted using complex models of the earths atmosphere. However such models contain many assumptions and simplifications and may not be good predictors. A model is more believable if it can simulate the past and present climates accurately. For example, Figure 3 compares recorded streamflows for the Mackenzie River with flows simulated by a hydrological model using recorded climate data (Kite, 1993) These agree well (lowest two lines). The model was then rerun using data from an atmospheric model for present day climate (1 x CO_2) and for a possible future climate (2 x CO_2). Unfortunately, the model shows a greater difference between the recorded and simulated present day conditions than between the two climate simulations. How then can we believe the atmospheric models predictions of the future?

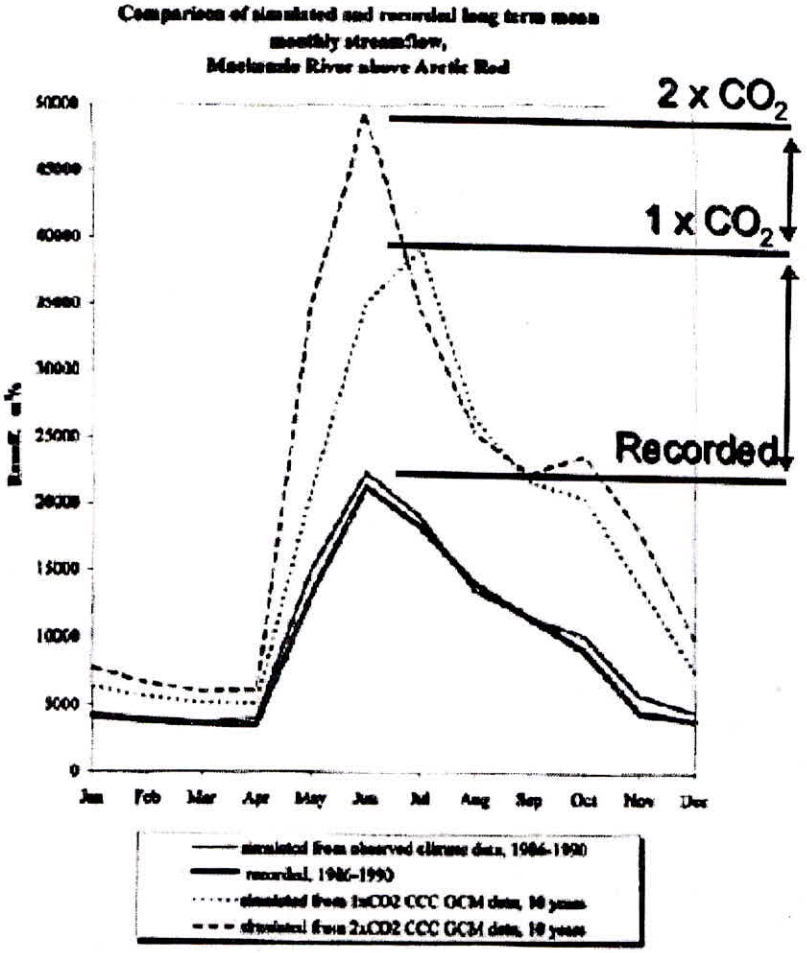

Figure 3. The difference between recorded and simulated present day conditions is greater than between simulated present and future conditions.

The effect of a change in climate on water resources would be to increase the uncertainty in the area where the curves of water supply vs. time and water demand vs. time intersect (Figure 4). Water demand gener ally increases with time as population and per capita consumptions increase. Water availability, on the other hand, has been considered relatively constant. Climate change may either increase or decrease water availability through changes in precipitation, temperature, cloudiness and humidity, increasing our level of uncertainty in the reliability of water resources projects.

However, as Klemes and Nemec (1983) have pointed out, water resources projects are already designed to include a large degree of uncertainty. It is reasonable to conclude therefore that, given the present state of uncertainty and the present tools available, climate change analysis can give only a very crude picture whose usefulness to water resources planning is extremely limited.

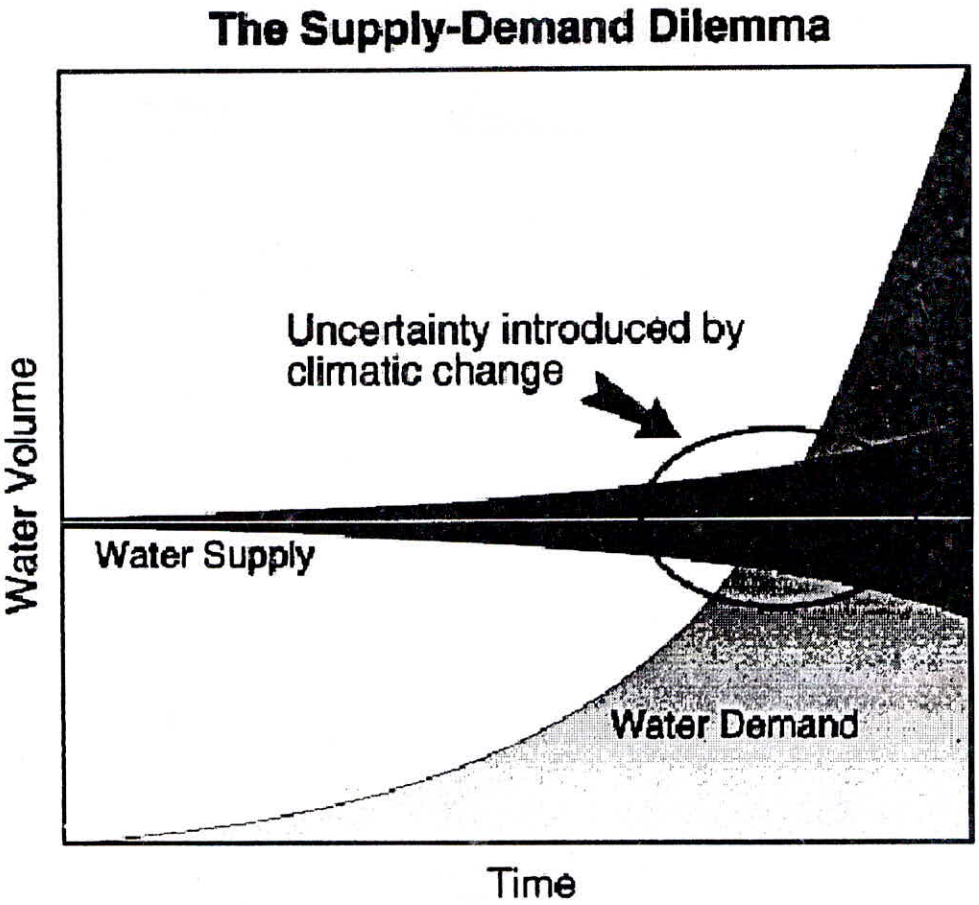

Figure 4. Climate change increases the uncertainty in the area where the water supply and water demand curves cross.

In summary, climate change is certain. Ten thousand years ago, the sites of most major North American and European cities were buried below hundreds of metres of ice. The view that climate change is bad and is due to man's thoughtlessness is simplistic. There may be (it is not certain and it cannot be measured) a small component of change due to increases in greenhouse gasses. For the design period of most water resources projects, the uncertainty due to climate change falls within normal design safety factors.

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