RALPH PENTLAND'S SPEAKING NOTES, APRIL 17, 2013

PRESENTATION TO THE ONTARIO POWER AUTHORITY BOARD OF DIRECTORS

WATER ISSUES AND ELECTRICITY GENERATION IN ONTARIO

I AM PLEASED TO HAVE THE OPPORTUNITY TO MEET WITH YOU TODAY.

BASED ON YOUR REQUEST, I HAVE PREPARED A FEW NOTES ON THREE SPECIFIC TOPICS, BUT WILL BE HAPPY TO DISCUSS ANY OTHERS THAT MAY COME UP DURING THE OPEN DISCUSSION. THE THREE SPECIFIC TOPICS ARE 1) ENERGY IMPLICATIONS OF GREAT LAKES WATER MANAGEMENT 2) CLIMATE CHANGE IMPLICATIONS FOR HYDROELECTRICITY PRODUCTION AND 3) IMPLICATIONS OF SHALE GAS REGULATION ON FUTURE NATURAL GAS PRICES.

BUT, BEFORE I GET INTO THOSE TOPICS, I SHOULD LIKELY SAY JUST A FEW MORE WORDS ABOUT MY BACKGROUND SO YOU WILL KNOW WHO YOU ARE LISTENING TO. I'VE REALLY HAD THREE DIFFERENT CAREERS. PRIOR TO 1991, I WAS DIRECTOR OF WATER PLANNING AND MANAGEMENT IN THE FEDERAL GOVERNMENT FOR 13 YEARS. IN THAT CAPACITY, I NEGOTIATED AND ADMINISTERED NUMEROUS FEDERAL-PROVINCIAL AND CANADA-U.S, WATER AGREEMENTS. I THEN SPEND MOST OF THE 1990S DOING MOSTLY INTERNATIONAL CONSULTING ALL AROUND THE WORLD, AND SINCE THE TURN OF THE CENTURY HAVE BEEN WORKING MAINLY WITH SEVERAL UNIVERSITIES AND NON-GOVERNMENTAL ORGANIZATIONS.

THE LAST TWO TIMES THAT I PLAYED AN OFFICIAL ROLE RELATED TO GREAT LAKES WATER MANAGEMENT ISSUES WERE IN 2002, WHEN I CO-CHAIRED THE IJC'S THREE YEAR REVIEW OF DIVERSIONS AND CONSUMPTIVE USES, AND IN 2001 AND 2002, WHEN I CO-CHAIRED THE IJC'S UPPER GREAT LAKES PLAN OF STUDY TEAM. PRIOR TO THAT, I PARTICIPATED IN THE GREAT LAKES LEVELS BOARD STUDY IN THE 1960S, CO-CHAIRED THE DIVERSIONS AND CONSUMPTIVE USES STUDY BOARD IN THE 1970S, AND CO-CHAIRED THE IJC PROTECTION OF THE WATERS OF THE GREAT LAKES STUDY GROUP IN 1999 AND 2000.

MORE RECENTLY, I WAS INVOLVED IN STATE-PROVINCIAL NEGOTIATIONS OF A GREAT LAKES DIVERSIONS REGIME, AND A COUPLE OF YEARS AGO, I ALSO DID A BIT OF CONSULTING WORK FOR

THE IJC'S UPPER LAKES STUDY BOARD, SO I AM SOMEWHAT, BUT NOT COMPLETELY UP- TO- DATE ON GREAT LAKES MATTERS.

1. ENERGY IMPLICATIONS OF GREAT LAKES WATER MANAGEMENT

WITH RESPECT TO GREAT LAKES WATER MANAGEMENT, WATER LEVELS HAVE SOME IMPLICATIONS RELATED TO THE HEAD AT POWER PLANTS AND PERHAPS TO SOME SHORELINE FACILITIES. BUT BY FAR THE MOST IMPORTANT IMPLICATIONS RELATE TO THE TIMING AND MAGNITUDE OF FLOWS THROUGH POWER PLANTS AND THEIR TURBINES AT SAULT STE. MARIE, NIAGARA FALLS AND CORNWALL.

SO, NOW I WOULD LIKE TO GET INTO FACTORS THAT HAVE OR ARE LIKELY TO CHANGE GREAT LAKES LEVELS AND OUTFLOWS. ONE TREND THAT IS COMPLETELY BEYOND OUR CONTROL IS GLACIAL REBOUND. THE GREAT LAKES WERE FORMED ABOUT 14000 YEARS AGO AFTER THE LAST ICE AGE WHEN THE GLACIERS RETREATED. THE BASIN CONTINUES TO REBOUND FROM THE WEIGHT THAT THE GLACIERS EXERTED ON IT MANY YEARS AGO. THIS REBOUND, REFERRED TO AS "CRUSTAL MOVEMENT" OR ISOSTATIC REBOUND HAS RESULTED IN THE NORTHEASTERN PART OF THE BASIN RISING RELATIVELY FASTER THAN THE SOUTHWESTERN PART.

ALTHOUGH THIS FACTOR IS UNCONTROLLABLE, IT DOES HAVE SOME IMPLICATIONS FOR THE CANADA - U.S. DYNAMIC. FOR EXAMPLE, THE LAND AROUND GEORGIAN BAY IS RISING AT A RATE OF ABOUT HALF A FOOT A CENTURY RELATIVE TO THE LAKE-MICHIGAN-HURON OUTLET. SINCE IT IS THE OUTLET ELEVATION THAT DETERMINES OUTFLOWS AND THEREFORE LAKE STORAGE, WATER LEVELS IN GEORGIAN BAY ARE EFFECTIVELY DROPPING AT THE RATE OF ABOUT HALF A FOOT A CENTURY.

CONVERSELY, CHICAGO'S LAND ELEVATION IS DECLINING RELATIVE TO THE LAKE OUTLET AT A RATE OF ABOUT HALF A FOOT A CENTURY. SO, THEIR WATER LEVELS ARE EFFECTIVELY RISING AT THAT RATE. THAT MAY AT LEAST PARTIALLY ACCOUNT FOR THE FACT THAT U.S. INTERESTS ARE SOMEWHAT LESS CONCERNED ABOUT LOW WATER LEVELS THAN THEIR CANADIAN COUNTERPARTS – AND LESS ANXIOUS TO TAKE MEASURES TO COMPENSATE FOR LOWERING LEVELS.

I MENTION THAT HERE BECAUSE THERE IS AN OUTSIDE CHANCE THAT MAY EVENTUALLY HAVE DIRECT IMPLICATIONS FOR HYDRO INTERESTS. SOME OF YOU MAY BE AWARE OF THE OUTRAGE OF GEORGIAN BAY PROPERTY OWNERS ABOUT DECLINING WATER LEVELS. MY GUESS IS THAT A COMBINATION OF CLIMATE CHANGE, DREDGING FOR NAVIGATION, CONSUMPTIVE USE OF WATER

AND CRUSTAL MOVEMENT MAY HAVE ALREADY LOWERED GEORGIAN BAY LEVELS BY CLOSE TO 3 FEET OVER THE PAST CENTURY.

THOSE OUTRAGED CITIZENS HAVE PROPOSED LOTS OF POTENTIAL SOLUTIONS, ONE OF WHICH WOULD BE TO INSTALL RUN-OF-THE-RIVER TURBINES IN THE ST. CLAIR RIVER THAT WHICH WOULD BOTH GENERATE ENERGY AND RAISE WATER LEVELS ON LAKES MICHIGAN AND HURON BY WAY OF ARTIFICIAL FLOW RESISTANCE. THE NATIONAL RESEARCH COUNCIL STUDIED THAT POSSIBILITY LAST YEAR, AND CONCLUDED THAT A MAXIMUM 19 CM RISE COULD BE ACHIEVED WITH 150 VERY LARGE TURBINES.

HOWEVER, THE DEPLOYMENT AREA WOULD BE IN FISH SPAWNING AREA AND THAT CONFIGURATION WOULD SIGNIFICANTLY DISRUPT SHIPPING. ACCORDING TO THE NRC, REDESIGNING THE CONFIGURATION TO AVOID THE ENVIRONMENTAL AND NAVIGATION PROBLEMS WOULD REDUCE THE LAKE LEVEL INCREASE TO ABOUT 5 CM. IN ANY EVENT, THE AMOUNT OF ENERGY PRODUCED WOULD BE VERY SMALL, IN THE ORDER OF 500 KW. DESPITE THESE DRAWBACKS, SOME VARIATION OF THIS OPTION MAY EVENTUALLY BECOME VIABLE IF WATER LEVELS CONTINUE TO DROP AND ENERGY COSTS ESCALATE ENOUGH.

FROM AN ENERGY PERSPECTIVE, BOTH VARIABILITY AND LONGER TERM TRENDS IN WATER LEVELS AND OUTFLOWS ARE IMPORTANT. MOST VARIABILITY IS NATURAL – BUT SUPERIMPOSED ON THAT NATURAL VARIABILITY IS LAKE LEVEL AND OUTFLOW REGULATION. TRENDS ARE CAUSED BY A VARIETY IF THINGS, INCLUDING WATER DIVERSIONS INTO OR OUT OF THE BASIN, WATER CONSUMPTION WITHIN THE BASIN, AND CLIMATE CHANGE.

LONG-TERM NATURAL FLUCTUATIONS RESULT FROM PERSISTENT LOW OR HIGH WATER SUPPLY CONDITIONS WITHIN THE BASIN. THEY CULMINATE IN EXTREMELY LOW OR HIGH LEVELS THAT MAY PERSIST FOR UP TO FIVE TO TEN YEARS OR MORE. SINCE THE LATE 90S, WE HAVE BEEN IN A PERIOD OF PERSISTENTLY LOW LEVELS, IN OTHER WORDS NEAR THE LOW END OF ABOUT A SIX FOOT RANGE OF STAGE ON THE LARGEST UNREGULATED LAKE, LAKE MICHIGAN-HURON.

BUT, THAT WILL NOT LAST FOREVER. THERE HAS BEEN A LOT OF SPECULATION OVER THE YEARS ABOUT WHETHER OR NOT THESE LONGER-TERM FLUCTUATIONS ARE PARTIALLY PREDICTABLE. FOR EXAMPLE, SOME SUGGEST A POSSIBLE THIRTY YEAR CYCLE, AND AS EVIDENCE POINT TO HIGH WATER IN THE 1950S AND 1980, AND LOW WATER IN THE 1930S, 1960S AND 1990S. THE MORE GENERAL VIEW IS THAT THESE EXTREMES ARE NOT PREDICTABLE.

SEASONAL FLUCTUATIONS SIMPLY REFLECT THE ANNUAL HYDROLOGIC CYCLE. THEY ARE CHARACTERIZED BY HIGHER NET BASIN SUPPLIES DURING THE SPRING AND EARLY SUMMER MONTHS, WITH LOWER NET BASIN SUPPLIES THROUGHOUT THE REMAINDER OF THE YEAR. THE MAGNITUDE OF THE SEASONAL VARIATION IS QUITE SMALL RELATIVE TO THE LONGER-TERM FLUCTUATIONS – ABOUT A FOOT ON THE UNREGULATED LAKE MICHIGAN HURON.

SUPERIMPOSED ON THE LONGER-TERM AND SEASONAL FLUCTUATIONS ARE OF COURSE SHORT-PERIOD FLUCTUATIONS CAUSED BY WINDS AND BAROMETRIC PRESSURE DIFFERENTIALS. THESE MIGHT LAST FROM A FEW HOURS TO SEVERAL DAYS, AND TEND TO BE THE CAUSE OF MOST FLOODING AND EROSION DAMAGES.

WE CAN'T CONTROL NATURAL WATER LEVEL FLUCTUATIONS TO ANY SIGNIFICANT DEGREE. IN FACT, THERE IS GROWING EVIDENCE THAT WOULD BE UNDESIRABLE EVEN IF WE COULD DO IT. A HEALTHY ECOSYSTEM REQUIRES BOTH SEASONAL AND LONGER-TERM LAKE LEVEL FLUCTUATIONS TO THRIVE. AND PEOPLE CAN LEARN TO ADAPT. FOR EXAMPLE, THEY CAN RESPECT NATURAL FLOODPLAINS AND NOT BUILD FLOOD-VULNERABLE UNDERTAKINGS ON THEM. AND THEY CAN DESIGN WATER INTAKES AND OTHER UNDERTAKINGS TAKING INTO ACCOUNT THE FACT THAT LOW WATER CONDITIONS WILL INEVITABLY REOCCUR AT SOME FUTURE DATE.

THE MOST OBVIOUS WAY THAT HUMANS AFFECT WATER LEVELS AND FLOWS VARIABILITY IS THROUGH LAKE LEVEL REGULATION. SINCE 1914, THE INTERNATIONAL LAKE SUPERIOR BOARD OF CONTROL HAS BEEN OVERSEEING LAKE SUPERIOR OUTFLOWS AND RESULTING LEVELS. SINCE COMPLETION OF THE ST. LAWRENCE SEAWAY I959, THE INTERNATIONAL ST. LAWRENCE RIVER BOARD OF CONTROL HAS BEEN OVERSEEING LAKE ONTARIO OUTFLOWS AND RESULTING LEVELS. BOTH OF THESE BOARDS REPORT REGULARLY TO THE INTERNATIONAL JOINT COMMISSION.

IN BOTH CASES, THERE ARE PLANS OF REGULATION IN PLACE WHICH PROVIDE SOME MEASURE OF PROTECTION TO SPECIFIC INTERESTS. FOR EXAMPLE, ENERGY INTERESTS ARE PROTECTED BY WAY OF MINIMUM FLOW REQUIREMENTS. FROM TIME TO TIME, THESE REGULATION PLANS ARE RE-EXAMINED AND REFINED. IF THERE IS A TREND IN THAT REGARD, IT IS IN THE DIRECTION OF MOVING THINGS A BIT CLOSER TO A STATE OF NATURE, BUT THAT SHOULDN'T HAVE ANY SIGNIFICANT IMPACT ON ENERGY INTERESTS.

IT IS IMPORTANT TO RECOGNIZE THAT LAKE LEVEL REGULATION DOES NOT CHANGE THE AMOUNT OF WATER FLOWING THROUGH THE SYSTEM, AND THEREFORE THE AMOUNT OF WATER FLOWING

THROUGH HYDRO TURBINES. BUT, IT DOES HAVE A MINOR EFFECT ON THE TIMING OF THOSE FLOWS. IT IS ALSO IMPORTANT TO RECOGNIZE THAT REGULATION CAN KEEP LONG-TERM AVERAGE LEVELS CONSTANT EVEN IF THERE ARE LONGER-TERM TRENDS IN NET SUPPLY. SO, FOR EXAMPLE, IF CLIMATE CHANGE WERE TO IMPACT SUPPLIES IN A SIGNIFICANT WAY, THE AVERAGE REGULATED LEVELS ON LAKES SUPERIOR AND ONTARIO COULD BE HELD CONSTANT. BUT, THE AVERAGE OUTFLOWS WOULD NECESSARILY ADJUST TO THE CHANGING SUPPLIES.

SINCE 1955, THE INTERNATIONAL NIAGARA COMMITTEE HAS BEEN OVERSEEING THE DISTRIBUTION OF NIAGARA RIVER FLOWS BETWEEN THE VARIOUS INTERESTS AT NIAGARA FALLS. THAT COMMITTEE REPORTS DIRECTLY TO GOVERNMENTS RATHER THAN THROUGH THE IJC, BUT NEVERTHELESS DOES KEEP ON TOP OF EVERYTHING THAT IS HAPPENING IN THE NIAGARA RIVER. EVEN THOUGH THE DISTRIBUTION OF FLOW BETWEEN THE VARIOUS INTERESTS IS REGULATED, THE TOTAL OUTFLOW THROUGH THE NIAGARA RIVER IS UNREGULATED.

BEFORE GETTING INTO THE HUMAN-INDUCED CAUSES OF LONGER-TERM CHANGES TO LAKE LEVEL AND OUTFLOWS, I NEED TO TOUCH ON A COMMON MISCONCEPTION – NOT NECESSARILY WITH THE PEOPLE IN THIS ROOM - BUT CERTAINLY AMONG THE GENERAL POPULATION. MANY PEOPLE SEEM TO THINK THAT IF YOU DIVERT A CONSTANT AMOUNT OF WATER OUT OF LAKE MICHIGAN-HURON, FOR EXAMPLE THE DIVERSION AT CHICAGO, THAT WILL CONTINUE TO LOWER THE LAKE LEVEL INDEFINITELY. AS I AM SURE MOST OF YOU REALIZE, THAT IS NOT THE CASE. THE LAKE OUTFLOW WILL EVENTUALLY ADJUST BY AN AMOUNT EQUAL TO THE CHANGE IN SUPPLY AS THE LAKE LEVEL LOWERS AND REACHES A NEW EQUILIBRIUM.

THERE ARE WATER DIVERSIONS BOTH INTO AND OUT OF THE GREAT LAKES. THE LONG LAC AND OGOKI DIVERSIONS WERE CONSTRUCTED IN 1941 AND 1943 RESPECTIVELY TO INCREASE CANADIAN HYDROPOWER CAPACITY CRITICAL TO PROVIDING MATERIALS FOR FIGHTING WORLD WAR II. THE WATER THAT IS DIVERTED INTO LAKE SUPERIOR, SOME 5600 CFS WOULD OTHERWISE FLOW FROM LONG LAC AND THE OGOKI RIVER INTO THE SALTWATER OF JAMES BAY. IF THOSE DIVERSIONS WERE CEASED, IT WOULD ADVERSELY IMPACT ON HYDROPOWER PRODUCTION AND LOWER WATER LEVELS IN THE GREAT LAKES.

WATER HAS BEEN DIVERTED OUT OF THE GREAT LAKES BASIN BY WAY OF THE CHICAGO DIVERSION SINCE COMPLETION OF THE ILLINOIS AND MICHIGAN CANAL IN 1848. THE ORIGINAL PURPOSE OF THE CANAL WAS TO PROVIDE NAVIGATION FROM THE GREAT LAKES TO THE MISSISSIPPI RIVER AND THE

GULF OF MEXICO. IN 1900, THE CITY OF CHICAGO COMPLETED THE CHICAGO SANITARY AND SHIP CANAL, A MUCH LARGER CHANNEL. IT ACTUALLY REVERSED THE FLOW, CAUSING LAKE MICHIGAN WATER TO FLOW INTO THE RIVER, FLUSHING RAW SEWAGE DOWN THE NEW CANAL ALONG WITH GREAT LAKES WATER, AND PREVENTING CHICAGO'S SEWAGE FROM REACHING THE GREAT LAKES. THIS DIVERSION IS CURRENTLY LIMITED TO 3200 CFS BY A U.S. SUPREME COURT ORDER.

THE NET EFFECT OF THE OGOKI, LONG LAC AND CHICAGO DIVERSIONS IS AN INCREASE OF SOME 5600 CFS IN THE LAKE SUPERIOR OUTFLOW, AND AN INCREASE OF ABOUT 2400 CFS IN THE LAKE ERIE AND LAKE ONTARIO OUTFLOWS. THEY ALSO SLIGHTLY INCREASE WATER LEVELS ON THE UNREGULATED LAKES MICHIGAN, HURON AND ERIE.

ANOTHER ISSUE THAT COULD BE VERY IMPORTANT TO ENERGY INTERESTS IS FUTURE INTERBASIN DIVERSIONS. IF MAJOR SOUTHWARD DIVERSIONS FROM THE GREAT LAKES BASIN WERE EVER PERMITTED, THE IMPACTS COULD BE FAR MORE SEVERE THAN ANYTHING YOU HAVE EXPERIENCED TO DATE. I THINK MOST OF YOU ARE GENERALLY AWARE OF THE RECENT HISTORY ON THAT ONE. IN 1999 AND 2000, I CO-CHAIRED AN IJC STUDY TEAM ON THE TOPIC. THE IJC RECOMMENDED THAT INTERBASIN DIVERSIONS SHOULD BE PROHIBITED WITH MINOR AND WELL-DEFINED EXCEPTIONS.

BUT ABOUT THE SAME TIME THE STATES AND PROVINCES WHO WERE NEGOTIATING AGREEMENTS ON THE SUBJECT ALSO RECEIVED DIFFERENT ADVICE FROM A SOUTHWESTERN U.S. LAW FIRM. THAT LEGAL ADVICE WAS, WITHOUT ACTUALLY SAYING IT, THAT EVERYONE IN THE WORLD OR AT LEAST IN THE UNITED STATES HAS ESSENTIALLY THE SAME LEGAL RIGHT TO GREAT LAKES WATER.

THE STATES AND PROVINCES USED BOTH SETS OF ADVICE. WHEN DRAFT AGREEMENTS CAME OUT FOR PUBLIC COMMENT IN 2004, THEY STARTED FROM THE LEGAL FIRM'S ADVICE, AND THEN ADDED SOME OF THE CONSTRAINTS SUGGESTED BY THE IJC. CITIZENS IN BOTH COUNTRIES, BUT MOSTLY IN CANADA REACTED QUICKLY, ANGRILY AND IN LARGE NUMBERS. THE PROVINCE OF ONTARIO THEN ISSUED A STATEMENT SAYING IT WOULD NOT AGREE TO ANYTHING WEAKER THAN WHAT THE IJC HAD RECOMMENDED. A NEW SET OF AGREEMENTS WERE NEGOTIATED AND SIGNED LATE IN 2005 BASED ON THE PRINCIPLE RECOMMENDED BY THE IJC - A PROHIBITION ON DIVERSIONS WITH MINOR AND WELL-DEFINED EXCEPTIONS.

THERE ARE TWO AGREEMENTS – ONE A COMPACT BETWEEN THE EIGHT GREAT LAKES STATES THAT IS LEGALLY BINDING BECAUSE IT HAS BEEN PASSED INTO LAW BY ALL EIGHT STATES AND THE U.S. CONGRESS. THE SECOND IS A NON-BINDING AGREEMENT BETWEEN THE EIGHT STATES AND TWO

CANADIAN PROVINCES. IN MY VIEW, THESE ARE VERY GOOD AGREEMENTS, WHICH SHOULD PROVIDE A REASONABLE LEVEL OF PROTECTION INTO THE FORESEEABLE FUTURE.

ANOTHER TREND AFFECTING THE GREAT LAKES SUPPLIES AND OUTFLOWS, AND THEREFORE HYDROPOWER PRODUCTION IS THE CONSUMPTIVE USE OF WATER WITHIN THE BASIN. OF COURSE, THIS ONE IS A DOUBLE-EDGED SWORD FOR THE ENERGY INDUSTRY. YOUR THERMAL PLANTS CONSUME WATER, AND WHATEVER WATER THEY CONSUME DOESN'T FLOW THROUGH THE TURBINES IN THE CONNECTING CHANNELS.

HOW MUCH WATER IS CONSUMED IN THE GREAT LAKES BASIN? WELL, IT'S ABOUT 4000 CFS. ABOUT 70 % OF THAT CONSUMPTION IS IN THE UNITED STATES AND 30-% IN CANADA. THE BIGGEST CONSUMERS ARE INDUSTRIAL INTERESTS AT ABOUT 25%, IRRIGATION AT ABOUT 30% AND PUBLIC WATER SUPPLIES AT ABOUT 30%. NUCLEAR THERMOELECTRIC AND FOSSIL-FUEL THERMOELECTRIC ARE AT ABOUT 8% EACH.

4000 CFS IS THE MAGNITUDE OF A MEDIUM-SIZED RIVER IN THIS COUNTRY, BUT THE GOOD NEWS IS IT'S ONLY ABOUT 2% OF THE FLOW OF A LARGE RIVER LIKE THE ST. LAWRENCE – SO THE DIRECT IMPACT ON HYDROELECTRIC PRODUCTION IS LIMITED. THE OTHER GOOD NEWS ABOUT CONSUMPTIVE USE IS THAT IT HAS LEVELED OFF SINCE ABOUT 1985, AND ISN'T INCREASING NEARLY AS QUICKLY AS IT DID BEFORE THAT.

2. CLIMATE CHANGE IMPLICATIONS FOR HYDROELECTRICITY PRODUCTION

A POTENTIALLY MUCH MORE SERIOUS ISSUE FOR THE ENERGY INDUSTRY IS CLIMATE CHANGE. MOST OF YOU ARE LIKELY SOMEWHAT FAMILIAR WITH THE THEORY OF CLIMATE CHANGE, BUT LET ME JUST SUMMARIZE HOW FORECASTS ARE MADE.

AS EARLY AS 1996, THE INTERNATIONAL PANEL ON CLIMATE CHANGE WAS ABLE TO REACH A CONSENSUS THAT "THE BALANCE OF EVIDENCE SUGGESTS THERE IS A DISCERNIBLE HUMAN INFLUENCE ON THE CLIMATE SYSTEM." SINCE THAT TIME, THAT CONSENSUS HAS SOLIDIFIED AND THERE IS NOW NEARLY BUT NOT COMPLETELY UNANIMOUS AGREEMENT WITHIN THE SCIENTIFIC COMMUNITY THAT THE PRIMARY DRIVER OF CLIMATE CHANGE IS INCREASING CONCENTRATIONS OF GREENHOUSE GASES IN THE ATMOSPHERE; AND THAT THE MOST SIGNIFICANT SOURCES OF THOSE GASES ARE THE BURNING OF FOSSIL FUELS AS WELL AS SOME FORESTRY AND AGRICULTURAL PRACTICES.

THERE IS ALSO NEARLY UNANIMOUS AGREEMENT THAT NORTHERN LATITUDES ARE WARMING AT A MUCH FASTER RATE THAN MOST OTHER AREAS BECAUSE OF INCREASING LEVELS OF GREENHOUSE GASES IN THE ATMOSPHERE, DECREASING SURFACE ALBEDO, CHANGES IN CLOUD COVER, AND ENHANCED TRANSPORT OF HEAT ENERGY POLEWARD BY ATMOSPHERIC WEATHER SYSTEMS. VARIOUS SCENARIOS OF PLAUSIBLE FUTURE EMISSIONS OF GREENHOUSE GASES HAVE BEEN POSTULATED. THESE SCENARIOS SUGGEST THAT ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES EQUIVALENT TO A DOUBLING OF CARBON DIOXIDE (CO_2) ARE ALMOST CERTAIN BY THE LATTER HALF OF THIS CENTURY. TRIPLING OR MORE IS A DISTINCT POSSIBILITY.

ORIGINALLY, CLIMATE IMPACT ASSESSMENTS USED SCENARIOS BASED ON EQUILIBRIUM $2XCO_2$ GENERAL CIRCULATION MODEL RUNS, IN WHICH THE ATMOSPHERIC CONCENTRATION OF CO_2 WAS INSTANTANEOUSLY DOUBLED. IN MORE RECENT YEARS, THE ATMOSPHERIC MODELS HAVE BEEN COUPLED WITH A FULLY THREE-DIMENSIONAL OCEAN MODEL, THUS ALLOWING TIME DEPENDENT ("TRANSIENT") RUNS. THE MODELS ARE CONTINUALLY BEING REFINED BY INCLUDING OTHER FACTORS, SUCH AS THE EFFECTS OF SULFATE AEROSOLS. ONCE THE ATMOSPHERIC MODELS ARE LINKED WITH HYDROLOGIC MODELS, IT IS POSSIBLE TO MAKE PROJECTIONS OF THE PROBABLE IMPACT OF CLIMATE CHANGE ON STREAMFLOW AND WATER LEVEL REGIMES.

THERE ARE ABOUT A DOZEN MAJOR CLIMATE MODELING GROUPS WORLDWIDE. IN SELECTING MODELS THAT ARE MOST APPROPRIATE FOR A SPECIFIC REGION, IT IS PREFERABLE TO SELECT THOSE THAT MOST CLOSELY REPLICATE OBSERVED CLIMATE CONDITIONS IN THAT REGION. THE GERMAN, CANADIAN AND BRITISH MODELS APPEAR TO BE FAVORED BY MOST RESEARCHERS THESE DAYS. ALTHOUGH MOST CLIMATE MODELS TEND TO GIVE SIMILAR DIRECTIONAL RESULTS, THE PREDICTED MAGNITUDE OF SHIFTS VARIES WIDELY. THEREFORE, FOR PRACTICAL REASONS, IT IS ADVISABLE TO SUPPLEMENT MODEL RESULTS WITH SIMPLE EXTRAPOLATIONS OF TRENDS IN OBSERVED DATA, ESPECIALLY IF THE FORECASTED PERIOD IS RELATIVELY SHORT – SAY 25 YEARS OR SO.

THERE ARE SOME THINGS WE CAN CONCLUDE WITH A RELATIVELY HIGH DEGREE OF CERTAINTY, AND OTHERS THAT ARE STILL MORE SPECULATIVE. FOR EXAMPLE, WHILE CHANGES IN SEASONAL AND ANNUAL AIR TEMPERATURES AND CHANGES TO THE TIMING OF ANNUAL FREEZE-THAW REGIMES HAVE BEEN CLEARLY DOCUMENTED, PREDICTED CHANGES IN OTHER CLIMATE VARIABLES SUCH AS PRECIPITATION AND ASSOCIATED EFFECTS ON RIVER FLOWS AND LAKE LEVELS HAVE NOT BEEN AS CONSISTENTLY OBSERVED TO DATE.

WITH RESPECT TO CHANGES THAT HAVE ALREADY BEEN OBSERVED, IN NORTHERN CANADA THE AVERAGE TEMPERATURE HAS INCREASED BY ABOUT 2°C AND THE AVERAGE WINTER TEMPERATURE HAS INCREASED BY SOME 4°C. BY CONTRAST, THE AVERAGE TEMPERATURE IN SOUTHERN CANADA LIKELY INCREASED BY 0.5 AND 1.5^{o}C.

LOOKING AHEAD, THERE IS A RELATIVELY HIGH DEGREE OF CONSENSUS ON PROBABLE FUTURE TEMPERATURE INCREASES. THE ARCTIC IS EXPECTED TO SEE SIGNIFICANT WARMING BETWEEN 2 TO 4°C BY 2020 AND 4.5 TO 8°C BY 2050, WHILE THE REST OF THE COUNTRY WILL EXPERIENCE A MORE MODERATE, BUT STILL NOTICEABLE 0.5 TO 2°C INCREASE BY 2020 AND 2 TO 4°C BY 2050. WITH RESPECT TO PRECIPITATION, THE MODELS SUGGEST THAT THE ARCTIC REGION WILL SEE A SIGNIFICANT PRECIPITATION INCREASE BY 2050. BY CONTRAST, BOTH SUMMER AND WINTER PRECIPITATION LEVELS WILL DROP IN MORE SOUTHERN REGIONS.

SO WHAT DOES ALL THAT MEAN FOR HYDROELECTRIC PRODUCTION IN THE GREAT LAKES BASIN? THE SHORT ANSWER IS, NOBODY KNOWS FOR SURE. I HAVE SEEN MODEL RESULTS RANGING FROM A DECREASE OF 40% TO ESSENTIALLY NO CHANGE IN THE FLOWS OF THE NIAGARA AND ST. LAWRENCE RIVERS. DATA ON TRENDS WOULD SUGGEST THE DROP IS ACTUALLY HAPPENING. MY BEST GUESS IS THAT WE HAVE ALREADY EXPERIENCED A DECREASE IN MEAN OUTFLOWS OF BETWEEN 5% AND 10% OVER THE PAST QUARTER CENTURY, AND THAT DECREASE COULD EASILY REACH AS HIGH AS 25% OR MORE DURING THIS CENTURY.

WHEN FACED WITH NUMBERS THIS LARGE AND AT THE SAME TIME WITH MAJOR UNCERTAINTIES IN THOSE NUMBERS, THE OBVIOUS QUESTION IS WHAT SHOULD ONE DO ABOUT IT. ABOUT 25 YEARS AGO, I CO-CHAIRED SOMETHING CALLED THE RESOURCE USE AND MANAGEMENT SUBCOMMITTEE OF THE INTERGOVERNMNTAL PANEL ON CLIMATE CHANGE. OUR JOB WAS TO DEFINE STRATEGIES FOR RESOURCE MANAGERS TO DEAL WITH UNCERTAINTIES SURROUNDING CLIMATE CHANGE. AT THAT TIME, I PERSONALLY CONCLUDED THAT RESOURCE MANAGERS SHOULD FOCUS MAINLY ON "NO REGRETS" STRATEGIES. BY "NO REGRETS" STRATEGIES, I MEAN DOING ALL THE THINGS WE SHOULD BE DOING ANYWAY, BUT DOING THEM FASTER AND BETTER.

FOR EXAMPLE, IN THE CASE OF GREAT LAKES WATER MANAGEMENT AND ENERGY PRODUCTION, THEY WOULD BE THINGS LIKE:

- MOVING AS QUICKLY AS PRACTICABLE TO LESS POLLUTING ENERGY ALTERNATIVES;

- TAKING THE USER AND POLLUTER PAYS PRINCIPLES MUCH MORE SERIOUSLY;
- CONSERVING AS MUCH ENERGY AND WATER AS POSSIBLE;
- KEEPING WATER WITHIN THE BASIN IN ORDER TO MAXIMIZE RESILIENCE TO DEAL WITH UNFORESEEN CIRCUMSTANCES;
- DEVELOPING MORE FLEXIBLE LAKE LEVEL REGULATION AND OTHER WATER MANAGEMENT STRATEGIES; AND
- REVERSING THE SERIOUS DEGRADATION OF OUR ENVIRONMENTAL POLICY, SCIENCE AND PLANNING CAPACITIES THAT WE HAVE WITNESSED IN RECENT YEARS.

I THINK ONTARIO, AND YOUR ORGANIZATION IN PARTICULAR, HAS SHOWN A LOT OF LEADERSHIP IN CANADA ON THE FIRST ITEM – MOVING TO LESS POLLUTING ENERGY ALTERNATIVES. I AM JUST A LITTLE CONCERNED THAT MAY NOT BE SUSTAINABLE UNLESS WE GET A LOT BETTER AT EXPLAINING IT IN THE LANGUAGE OF GREED – OR IN OTHER WORDS IN ECONOMIC TERMS. LET ME GIVE YOU JUST ONE EXAMPLE.

ENVIRONMENTAL ECONOMISTS AT VERMONT'S MIDDLEBURY COLLEGE AND YALE UNIVERSITY IN CONNECTICUT HAVE CREATED A MEASURE OF INDUSTRY'S "GROSS DOMESTIC DAMAGES" OR GED. THIS NOVEL IDEA CAPTURES THE DAMAGES CAUSED BY AN INDUSTRY THAT IS NOT REFLECTED IN ITS BALANCE SHEET OR IN ECONOMIC STATISTICS LIKE THE GDP. FOR A FEW INDUSTRIES, INCLUDING COAL- AND OIL-FIRED POWER PLANTS, THE RATIO OF GED TO GDP EXCEEDED ONE. THE WORST CASE WAS THAT OF LIQUID PETROLEUM USED TO GENERATE ELECTRICITY. ITS FULL COST TO AMERICA'S ECONOMY OUTWEIGHED ITS CONTRIBUTION BY MORE THAN FIVE TO ONE.

3. IMPLICATIONS OF SHALE GAS REGULATION ON FUTURE NATURAL GAS PRICES

SO, NOW I WOULD LIKE TO MOVE TO THE SUBJECT OF FRACKING. WILL FUTURE REGULATION INCREASE NATURAL GAS PRICES? REGULATION PROBABLY WON'T INCREASE COSTS SIGNIFICANTLY, BUT A LACK OF CREDIBLE SCIENCE MIGHT. LET ME EXPLAIN.

ALTHOUGH ONTARIO HAS YET TO SEE SIGNIFICANT SHALE GAS EXPLORATION, THERE IS SIGNIFICANT POTENTIAL FOR SHALE GAS FROM THE KETTLE POINT, MARCELLUS AND COLLINGWOOD SHALES. ONTARIO'S SHALE FORMATIONS ARE SHALLOW AND THEREFORE CLOSER TO FRESHWATER AQUIFERS. BECAUSE THEY ARE SHALLOW, THEY ARE ALSO UNDER LESS PRESSURE THAN DEEPER FORMATIONS AND LIKELY TO YIELD LESS GAS. ANY WATER USED IN A AS WELL THAT WAS FRACKED WOULD LIKELY

REQUIRE APPROVAL UNDER ONTARIO'S WATER RESOURCES ACT AND REGULATIONS. BUT BEYOND THAT REGULATORY REQUIREMENTS IN ONTARIO AND THE REST OF CANADA ARE WOEFULLY WEAK.

IN BOTH CANADA AND THE U.S., SHALE GAS HAS MIGRATED FROM FRACKING OPERATIONS INTO AQUIFERS AND NEARBY DRILLING SITES. INDUSTRY HAS CONSUMED BILLIONS OF GALLONS OF PUBLIC WATER FOR FREE AND OFTEN IN WATER SCARCE REGIONS. CHEMICAL AND WASTEWATER SPILLS HAVE POLLUTED RIVERS AND KILLED FISH IN SHALE GAS ZONES. A SPECTACULAR RISE IN THE VOLUME OF TOXIC WASTE WATER PRODUCED BY FRACKING OPERATIONS AS WELL AS INCREASING PROBLEMS WITH GAS MIGRATION IN OLDER PETROLEUM FIELDS NEAR SHALE GAS FRACKS HAS ALSO STYMIED REGULATORS.

EVEN IF GOVERNMENTS ARE SLOW OFF THE MARK, MORE AND MORE EFFECTIVE REGULATION IS INEVITABLE. THE INDUSTRY IS FACING AN INCREASING NUMBER OF LAWSUITS, AT THE SAME TIME, INSURANCE COMPANIES ARE BECOMING INCREASINGLY WARY OF INSURING AN INDUSTRY WHERE THE "RULES OF THE ROAD" ARE UNCLEAR. AS LAWSUITS ESCALATE, ETHICAL INVESTMENT FUNDS AND INVESTOR-BACKED NON-PROFIT ORGANIZATIONS ARE PUSHING FOR FULL DISCLOSURE OF WATER AND CHEMICAL USE IN THE FRACKING INDUSTRY. UNDER THOSE CIRCUMSTANCES, IT SEEMS TO ME THE INDUSTRY ITSELF WOULD BENEFIT FROM CLEARER RULES.

FOR ANYONE INTERESTED IN WHAT FUTURE FRACKING REGULATIONS MIGHT LOOK LIKE, AN EXCELLENT REPORT WAS ISSUED ON THIS TOPIC JUST A COUPLE OF WEEKS AGO FROM THE CENTRE FOR LAW, ENERGY AND ENVIRONMENT AT THE BERKELY SCHOOL OF LAW IN CALIFORNIA. THAT REPORT MAKES FIVE IMPORTANT OBSERVATIONS:

1. FIRST, INCREASED TRANSPARENCY IS CRITICAL TO ALLOW COMMUNITIES TO EVALUATE AND RESPOND TO POTENTIAL RISKS, AND FOR REGULATORS AND EMERGENCY RESPONDERS TO MINIMIZE AND BE PREPARED TO DEAL WITH CONTAMINATION EVENTS.
2. SECOND, BECAUSE WELL CASING AND CEMENTING FAILURE IS A PRIMARY RISK FOR UNDERGROUND CONTAMINATION, STRINGENT TESTING AND MONITORING OF WELL INTEGRITY IS ALSO CRITICAL.
3. THIRD, BASELINE WATER TESTING AND COMPREHENSIVE INFORMATION ON THE CONTENTS OF FRACKING FLUID ARE NECESSARY TO DETERMINE WHETHER A POTENTIAL CONTAMINATION EVENT HAS OCCURRED AND WHICH PARTY IS RESPONSIBLE.

4. FOURTH, FRACKING TECHNOLOGIES ARE RAPIDLY EVOLVING – THIS CHANGING TECHNICAL LANDSCAPE IS DIFFICULT TO REGULATE EFFECTIVELY WITHOUT GREATER KNOWLEDGE OF THE EVOLVING TECHNIQUES AND THEIR ATTENDANT RISKS.
5. AND FIFTH, IT MAY IN SOME CIRCUMSTANCES BE NECESSARY TO SLOW THE GROWTH OF FRACKING ACTIVITY UNTIL MORE KNOWLEDGE CAN BE DEVELOPED.

IN MY VIEW, MORE STRINGENT REGULATION IS INEVITABLE, BUT THAT ALONE WON'T NECESSARILY SIGNIFICANTLY INCREASE COSTS. FOR ONE THING, THE COST OF FRACKING HAS DROPPED DRASTICALLY OVER THE PAST FIVE YEARS AS TECHNOLOGIES HAVE IMPROVED. ALSO, BASED ON MY OWN PERSONAL OBSERVATIONS OVER THE PAST SEVERAL DECADES, WELL-DESIGNED ENVIRONMENTAL REGULATION SELDOM INCREASES COST. WHAT IT MORE OFTEN DOES IS REDUCE WASTE AND INCREASE INNOVATION AND PRODUCTIVITY.

WHAT IS MORE LIKELY TO INCREASE COST IS A LACK OF KNOWLEDGE ABOUT RISK. IN THE U.S., THAT LACK OF KNOWLEDGE RELATES MOSTLY THE ATTENDANT RISK OF RAPIDLY EVOLVING TECHNOLOGIES. IN CANADA, THAT LACK OF KNOWLEDGE IS COMPOUNDED BY A WOEFULLY WEAK GROUNDWATER SCIENCE MORE GENERALLY. WHEN RISKS CANNOT BE DEFINED, PUBLIC OPPOSITION GROWS. THAT IS PRECISELY WHAT LED TO A MORATORIUM ON FRACKING IN QUEBEC. THE POLITICAL AND ECONOMIC COSTS OF A FRACKING MORATORIUM CAN BE SIGNIFICANT.

I THINK I WILL STOP FOR NOW. I WOULD BE HAPPY TO TRY AND ANSWER ANY QUESTIONS YOU MAY HAVE – OR TO LISTEN TO YOUR OPINIONS ON ANY OF THE TOPICS THAT I HAVE TOUCHED ON – OR ANY OTHES.

THANK YOU.