PEI Water Extraction Policy

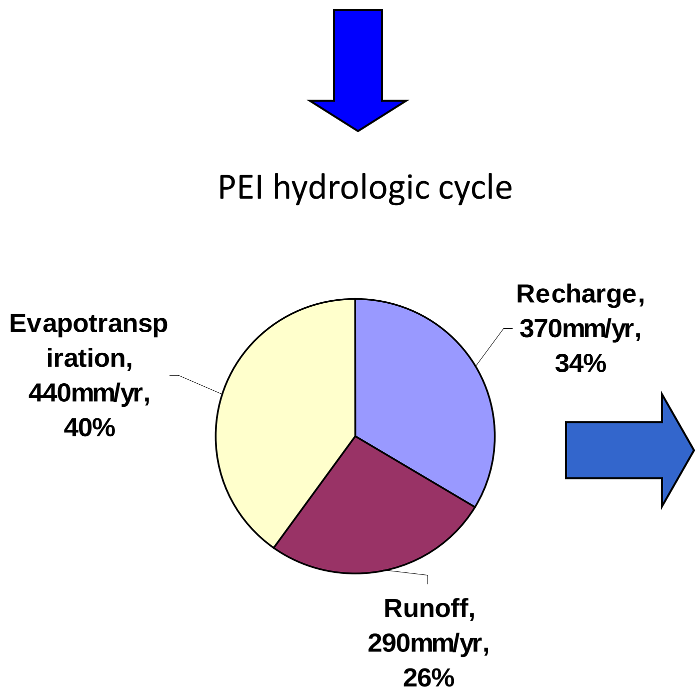
Department of Environment, Labour and Justice

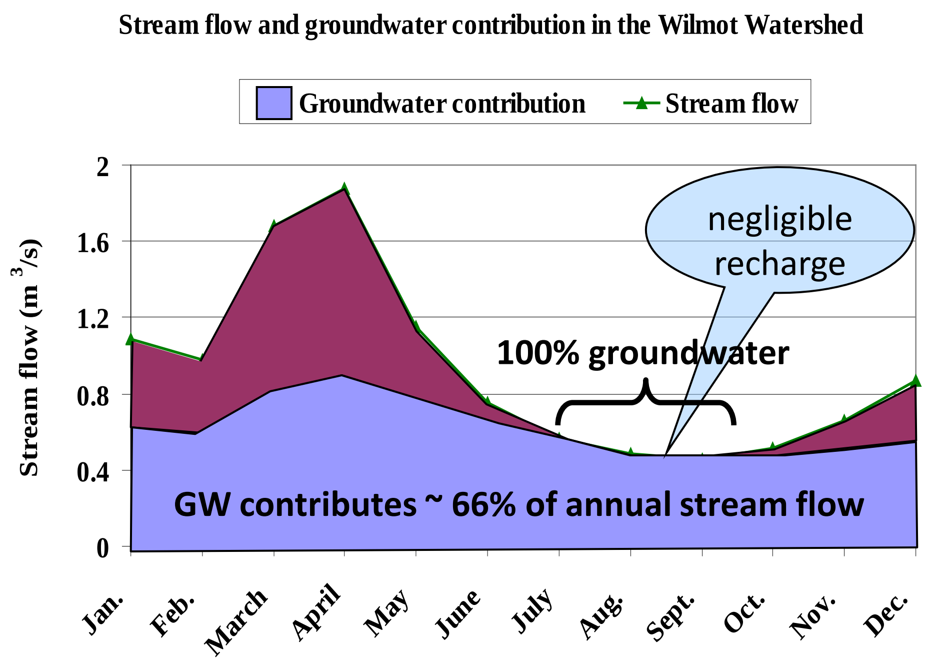
January, 2014

Hydrologic Cycle & Groundwater Resources

Precipitation: 1100 mm/yr.

PEI hydrologic cycle





- **PEI has abundant groundwater recharge, approximately 2 billion m³ / year.**
- **Charlottetown uses 7 million m³ / year.**

Background: Hydrologic Cycle & Groundwater Resources

- The slide shows a typical water budget for PEI including the processes and timing by which water is directed to different compartments in the environment.

- Precipitation and total stream flow has been measured directly at meterologic (12+) and hydrometric stations (5) operated by Environment Canada for many years.

- Groundwater elevation has been measured directly at 16 groundwater observation wells by the Province, with periods of record for some locations dating back to the 1960's.

- Groundwater and surface water stations are located in a coordinated network of "index basins" that represent geographic / physiographic regions of the Province.(Environment Canada – PEI DOE, 1991)

- Groundwater recharge, and direct run-off cannot be measured directly, but are calculated from measurements of total stream flow and groundwater elevations.

- Evapotranspiration has been measured directly, but is now often calculated from standard meteorological data.

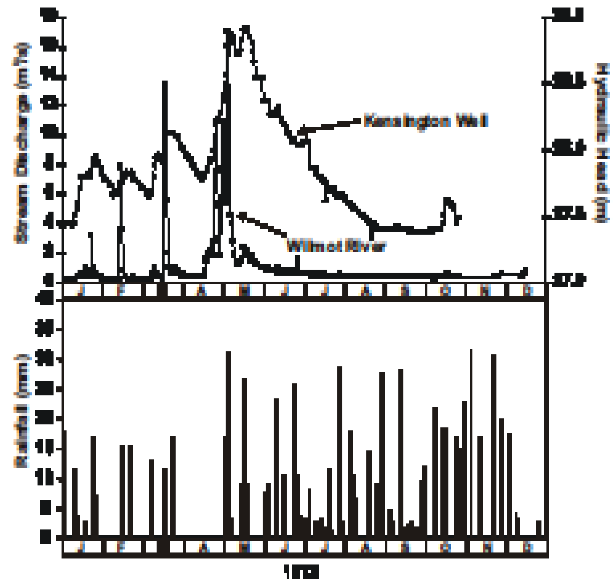


Figure 4 – Hydrograhs of the Kensington well and Wilmot River for 1972 which are representative for the Wilmot watershed flow system (top graphs). The hydrographs are compared to the precipitation amounts for 1972.

Background: Hydrologic Cycle & Groundwater Resources

- Estimates of annual groundwater recharge rates have been derived by a number of researchers from different organizations over the past 2 to 3 decades and are all in the same range (Francis, 1989, Jiang et al 2004, Somers and Savard, 2011,Rivard *et al*, 2008, 2013).

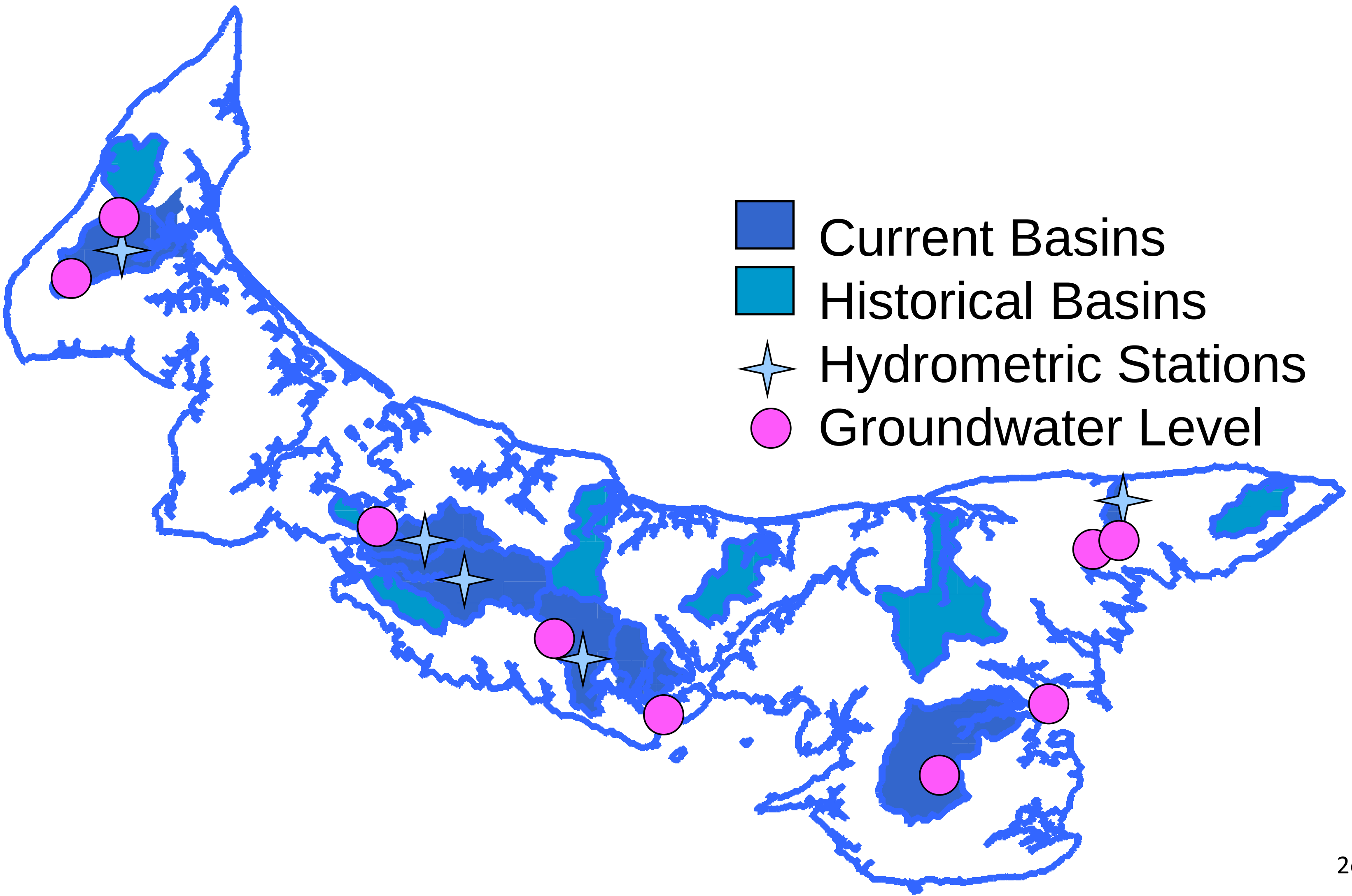
- Recharge rates are variable across the Province, but on average, are in the range of 35% of annual precipitation ...or around 400 mm year (Francis, 1989, Jiang et al 2004, Vigneault et al, 2007, Rivard et al, 2013)
- These values are high compared to many other jurisdictions:
  - PEI recharge 21 to 43% of precipitation vs Annapolis Valley 15.5%, Fredericton, NB, 13% (Rivard et al 2013)
  - Typical range across the county = 10% to 30% of precipitation (Rivera and Vigneault, 2010)

- The amount or rate of recharge is a result of the competing factors of infiltration of precipitation & snow melt, evapotranspiration and groundwater discharge (Jiang et al, 2013), resulting in significant **seasonal differences** in the amount of recharge.

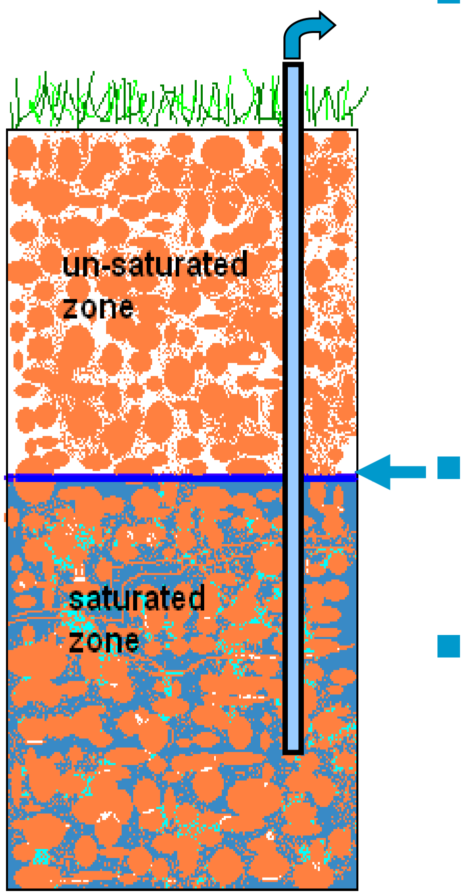
- The main periods of groundwater recharge occur in the spring (when infiltration from precipitation and snow melt are much greater than evapotranspiration), and to a lesser extent when infiltration of precipitation is greater than evapotranspiration. During the summer evaportranspiration is much greater than precipitation and, there is little recharge (Somers and Savard, 2009, 2010).

- The lack of significant summer recharge is demonstrated by the lack of discharge from tile drain networks during much of the summer, even during periods of significant rainfall, at experimental sites such as the Harrington Experimental Farm and the Souris WEB's sites, suggesting that most infiltrating precipitation is not leaving the root zone during this period of the year.

Background: Hydrologic Cycle & Groundwater Resources – Index basins



Groundwater: Some Terms



- The area below the ground surface can be divided into two zones:
  - **Un-saturated** zone where pore spaces and fractures in rocks and soil are partially filled with air, and partially filled with water.
  - **Saturated zone** where these void spaces are completely filled with water…what we call groundwater.
- The "**water table**" is simply the boundary between the un-saturated zone and the saturated zone.
- The geological formation containing this groundwater is called an "**aquifer**". We tap the groundwater contained in an aquifer by wells…simply conduits into the "**saturated zone**"

Typical Groundwater Flow System

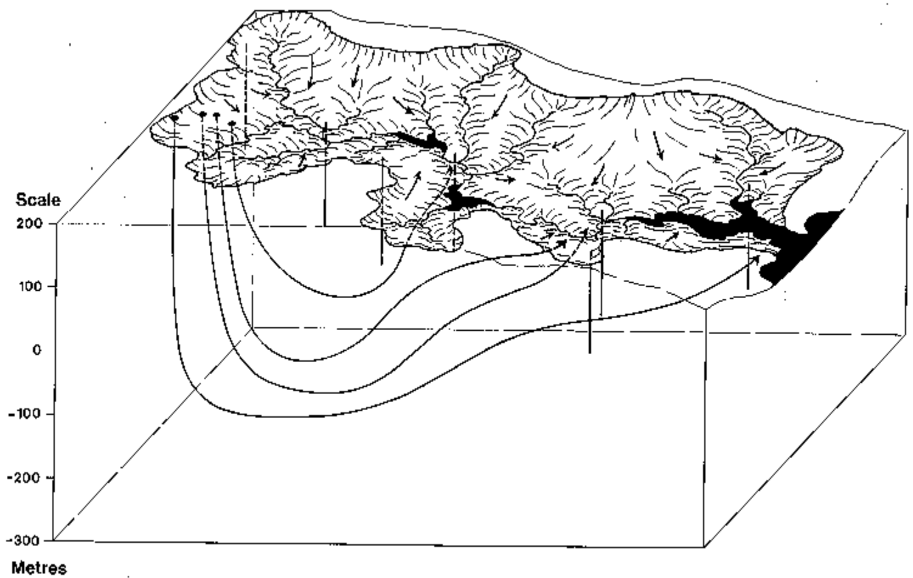
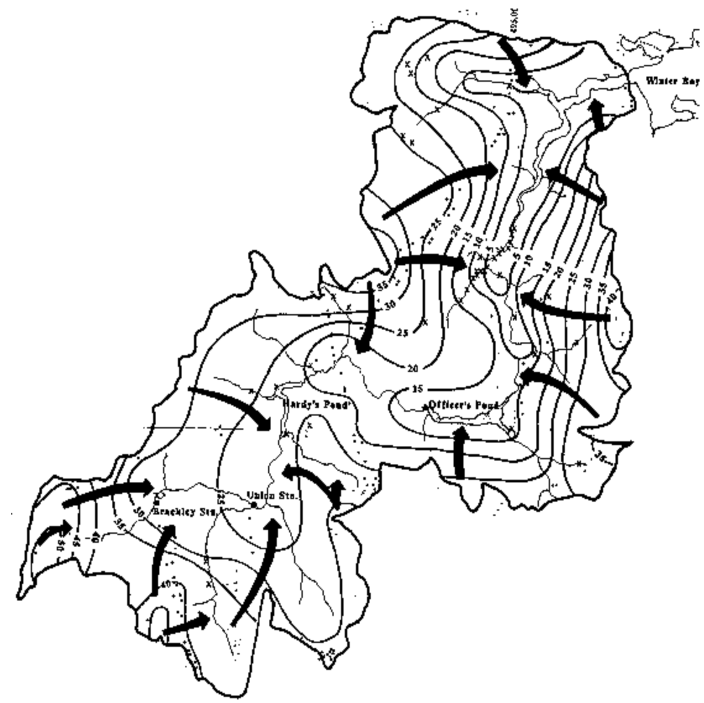
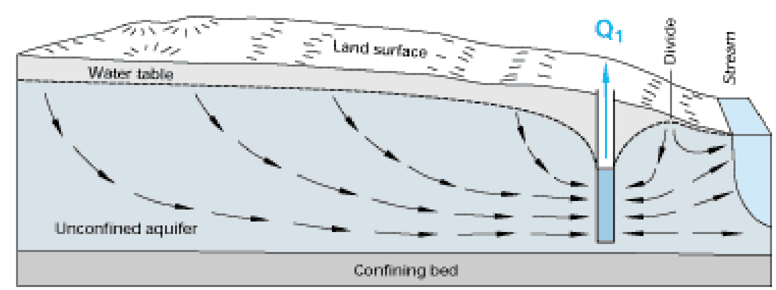


Figure 66. Three dimensional schematic of groundwater flow, Winter River basin.





- Pumping intercepts groundwater discharge that would otherwise feed surface water
- Intensive pumping can have impacts on nearby streams and environment.

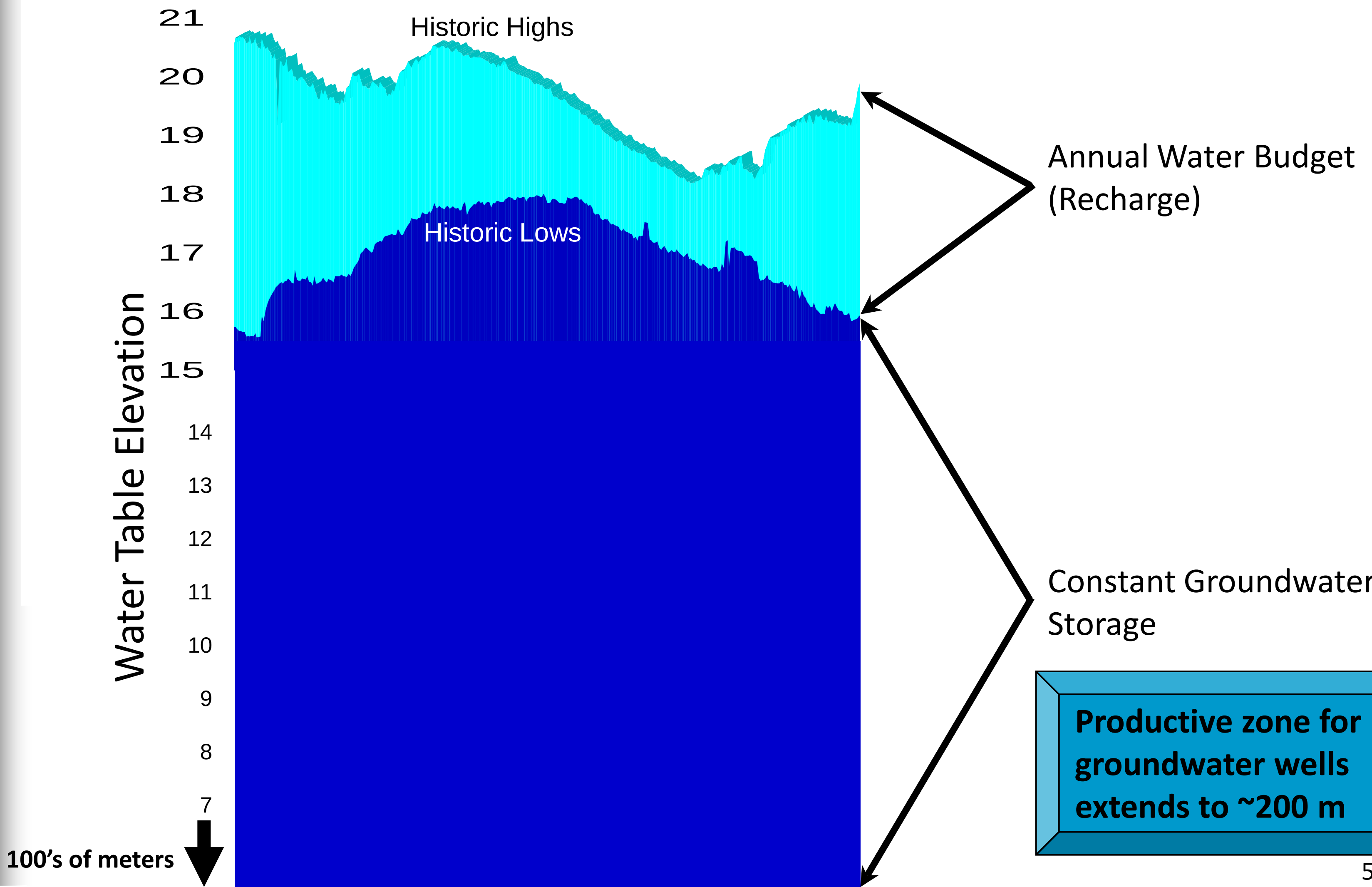
Background: Typical Groundwater Flow System

- Groundwater is not static but flows through the aquifer from recharge areas to discharge points at streams and the coast.
  - Groundwater discharge accounts for 2/3 of annual stream flow
  - Numerical modelling in the Summerside area suggests that submarine groundwater discharges into the Northumberland Strait constitutes approximately 13% of the total freshwater discharge to the sea.(Hansen and Ferguson,2012)
  - Pumping water from wells simply diverts a portion of this water from its normal pathway.

- In PEI, groundwater flow directions and rates are controlled primarily by fractures in the bedrock (Francis 1989, Jiang and Somers, 2008, Rivard *et al.* 2013) and the configuration of the water table.
  - We can measure the height of the water table directly, and calculate groundwater flow directions (in three dimensions) and velocities using numerical modelling [see for example Jiang *et al, 2007*]

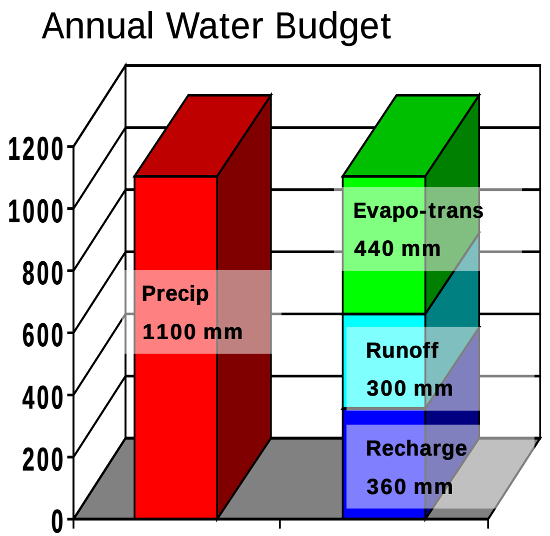
- Residence time in the aquifer:
  - **Shallow** water circuits through the aquifer very quickly
    - Matching seasonal changes in oxygen ($\delta^{18}O$) isotopes in nitrate in both groundwater and surface water (Savard et al, 2007, 2009, Somers and Savard, 2011).
    - Numerical modelling suggests that 80% of baseflow is from shallow portions of the aquifer (less than 22 m) with residence times being measured in terms of days adjacent to streams and overall of less than 4 years.(Jiang *et al*, 2007)
  - Water in **deeper** portions of the aquifer circulates more slowly
    - Samples from a depth of 100 m in the Wilmot have isotope dates (tritium) indicating they are at least 50 years old, and nitrate concentrations are consistent with periods that predate extensive fertilizer use (Savard and Somers, 2007).

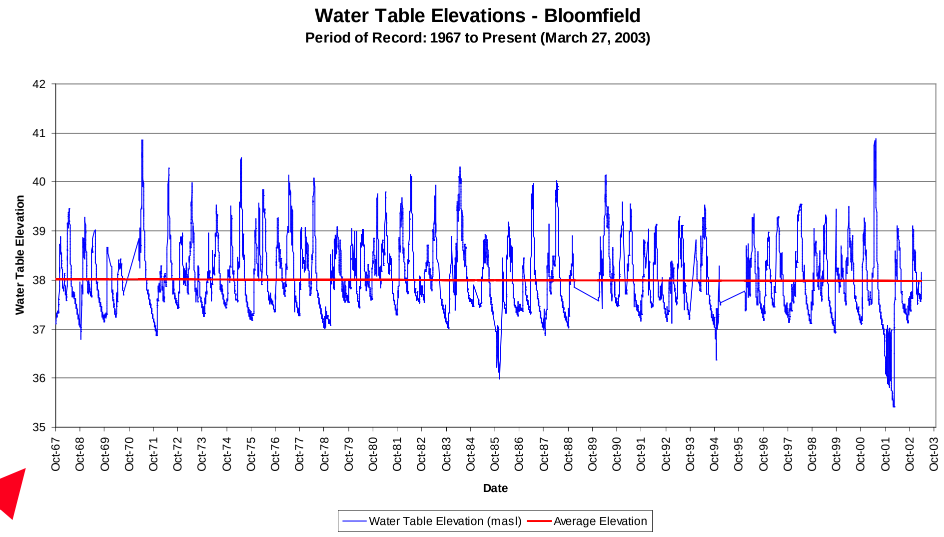
Groundwater Storage And Annual Fluctuations



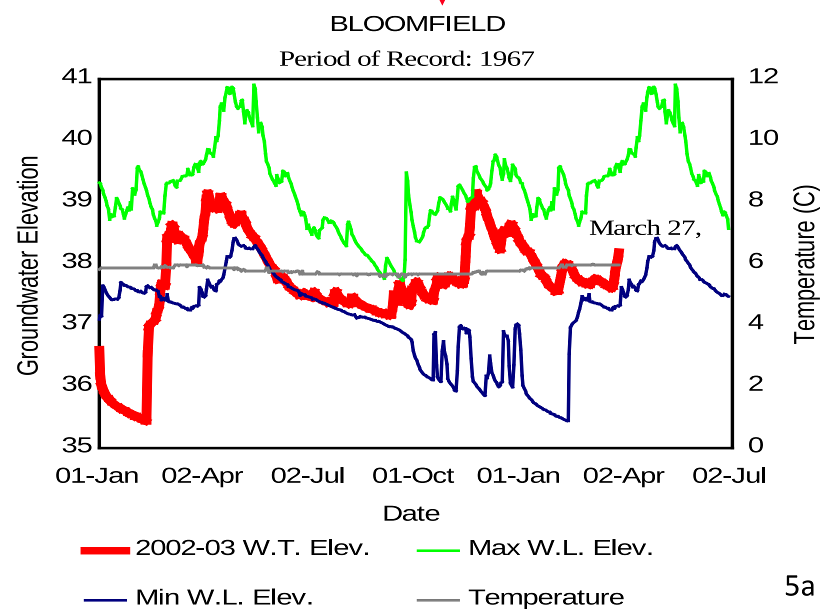
Productive zone for groundwater wells extends to ~200 m

Background: Groundwater Storage And **Annual Fluctuations**





- Long term data used to determine maximum and minimum water table elevations.
- These data describe the annual <u>changes</u> in groundwater quantity in the aquifer…<u>not</u> the total amount of groundwater available



Background: Groundwater Storage and Annual Fluctuations

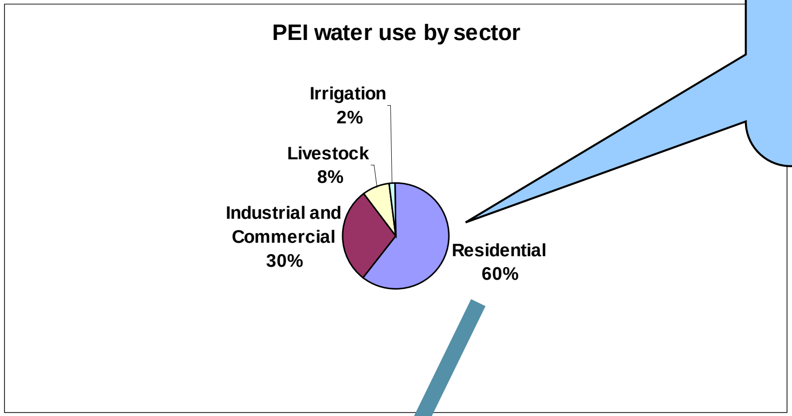
- Groundwater storage (ie total volume of groundwater available) is a function of the porosity (% void spaces) of the aquifer. The porosity of PEI's aquifer is 15% (Francis, 1989, Rivard, 2013). Thus every cubic metre of the aquifer contains about 150 litres of ground water.

- The formation that makes up PEI's aquifer is at least 800m thick (Van de Poll, 1983, Francis 1989), however:
  - Permeability, the ability to transmit water, mostly through fractures, declines with depth due to reduced fracture frequency and size (Francis, 1989, Paradis et al, 2007).
  - As a consequence, relative water yields to wells decline with depth and highly productive portions of the aquifer are generally limited to the upper 200 m of the formation (Jiang and Somers, 2008).

- Comparing:
  - annual fluctuations in water table elevation (in the order of 5 m), with
  - the total amount of water stored in the aquifer (in the range of 200 m)

  It shows that the proportion of groundwater that cycles through the aquifer on an annual basis is very small compared to the overall amount of water stored in the aquifer.

Use of Water on PEI



Municipal / Residential water use: 189 L/day/pp
(national average 274 L/d/pp)

Non- residential water use: 316 L/day/pp
(national average 236 L/day/pp)

<u>Breakdown of residential use</u>:
4% - Drinking/cooking
28% - Bathing and personal use
23% - Laundry and dishes
45% - Toilets

- Of the groundwater we extract Island wide:
  - 2% is consumed directly by humans
  - 58% is used for other sanitary purposes required to support human health
  - 40% is used for industry, irrigation, etc.

Background: Use of Water on PEI

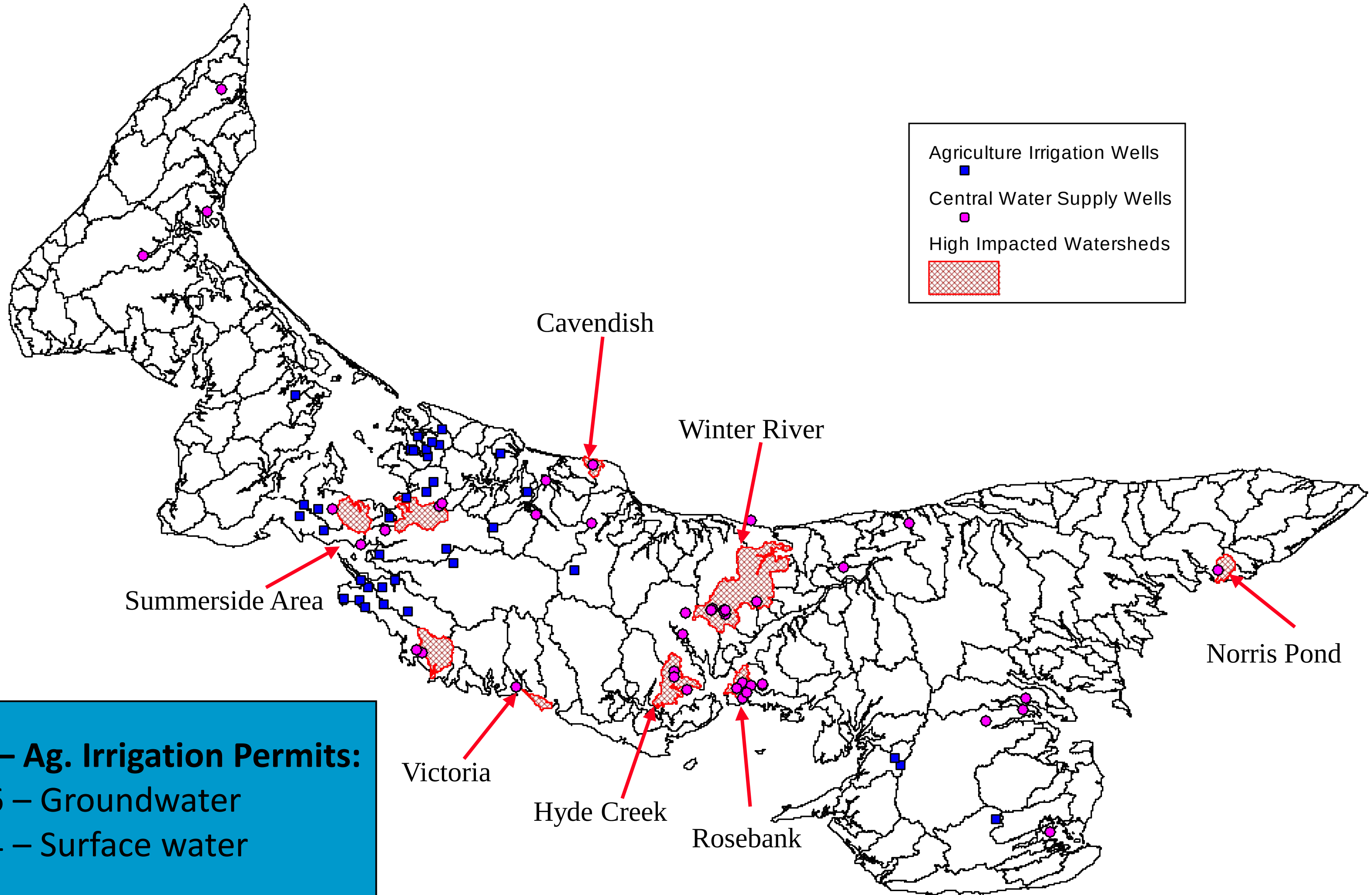
- Values for PEI residential and industrial water use are derived from Environment Canada data *(2011 Municipal Water Use Report, Municipal Water Use 2009 Statistics)* The values apply to municipal water utilities and are derived from statistics for total per capita use and residential per capita use. Commercial and industrial use is derived by subtracting residential use from total water use.

- Values for household use from general literature

- Values for water use by sector calculated as part of a Groundwater Sustainability Project (Li et al, 2013) conducted under the auspices of CCME.
  - Residential use calculated as:
    - *Total abstraction = Groundwater Extraction Permit for high capacity wells + Number of house holds using private well * 2.13*0.37 m3/day * 365.25 day/year*
  - Industrial and commercial use from
    - *Groundwater Extraction Permits + proportion of industrial and commercial use reported by Charlottetown and Summerside water utilities + institutional*
  - Irrigation use
    - *Includes both agriculture and golf courses. Agriculture is ~1% alone – this value is based upon records from the Baltic area (97-98) scaled up for the total number of agricultral irrigation wells on PEI.*
  - Livestock use calculated as
    - *number of animals x consumption representative of individual species*

- *Total agricultural sector use (irrigation, livestock, food processing) is ~ 21%*

Watersheds With High Water Demand



60 – Ag. Irrigation Permits:

36 – Groundwater

24 – Surface water

Water Extraction Policy (2010)

- Purpose
  - Provide for orderly and sustainable* use of the Province's water resources

    *Sustainable - meets ecological and human needs

- Scope
  - Criteria for acceptable withdrawal of groundwater and surface water
  - Provides a process for application of the criteria
  - Accounts for watershed variability by using watershed specific base flow

Background: Water Extraction Policy

- The full text of the water extraction policy is contained in the document entitled Water Extraction Permitting Policy (Environment, Labour & Justice). See references for website location.

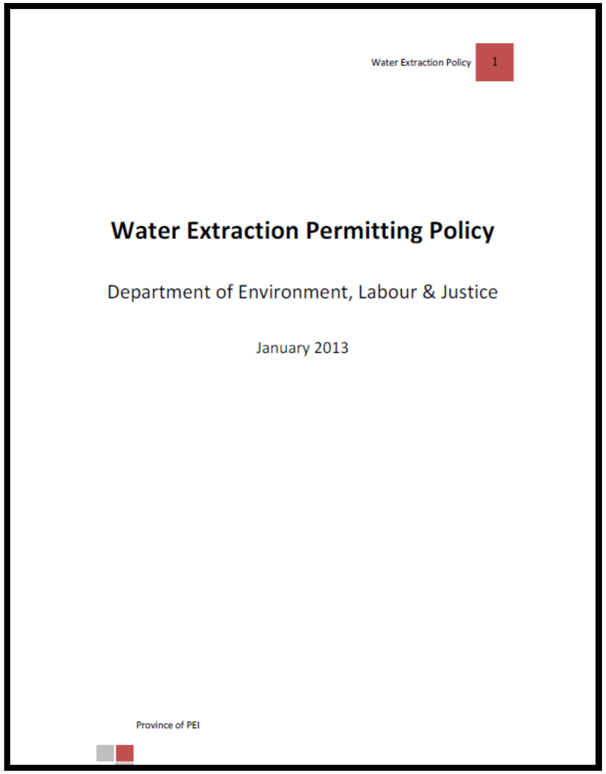
- Three reports by the Canadian Rivers Institute (Curry, *et al*, 2006, Curry and Gautreau, 2008, Monk and Curry, 2009) that informed the crafting of the policy are also available on the website.

Water Extraction Policy Goals

- **Science Based**
  - Consistent approach across the Province
  - Integrates groundwater and surface water considerations
  - Addresses regional hydrologic variability
- **Balanced**
  - Reasonable balance between human needs and ecological considerations
- **Practical Process**
  - Does not place an un-reasonable burden on proponents
  - Process for determination is manageable by Department
  - Process allows for verification of initial estimated impacts
- **Predictable**
  - “Screens out” unrealistic expectations for water allocation at the start
  - Provides water users with reasonable assurance of supply in the long term

Water Extraction Policy

- Water Use Priorities
  1. Fire Protection
  2. Drinking Water
  3. Environment (maintenance of ecosystems)
  4. Industrial (including agricultural irrigation)



Water Extraction Policy 1

Water Extraction Permitting Policy

Department of Environment, Labour & Justice

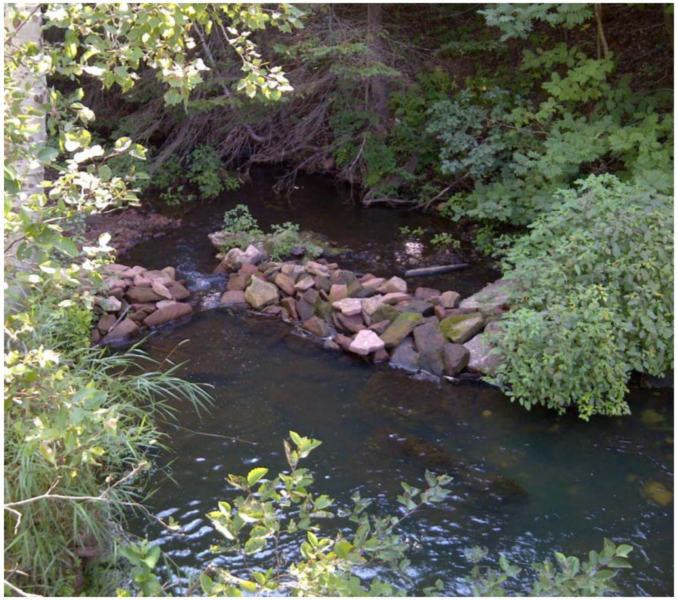
January 2013

Province of PEI

- Permitting Criteria
  - Stream flow is more sensitive than groundwater levels
  - Criteria based on protecting stream habitat
  - Protective of groundwater levels as well as stream habitat.

Availability of Surface Water

- Limited high volume sources of fresh water dictated by geography
- Significant variability in seasonal flow
  - Max flow available when water not needed
- Summer flows highly dependant on groundwater discharge (base-flow)
  - No flow available when needed most
- Excessive use has immediate impact on aquatic life
- Surface Water Criteria
  - Maintenance Flow – 70% of the median monthly stream flow



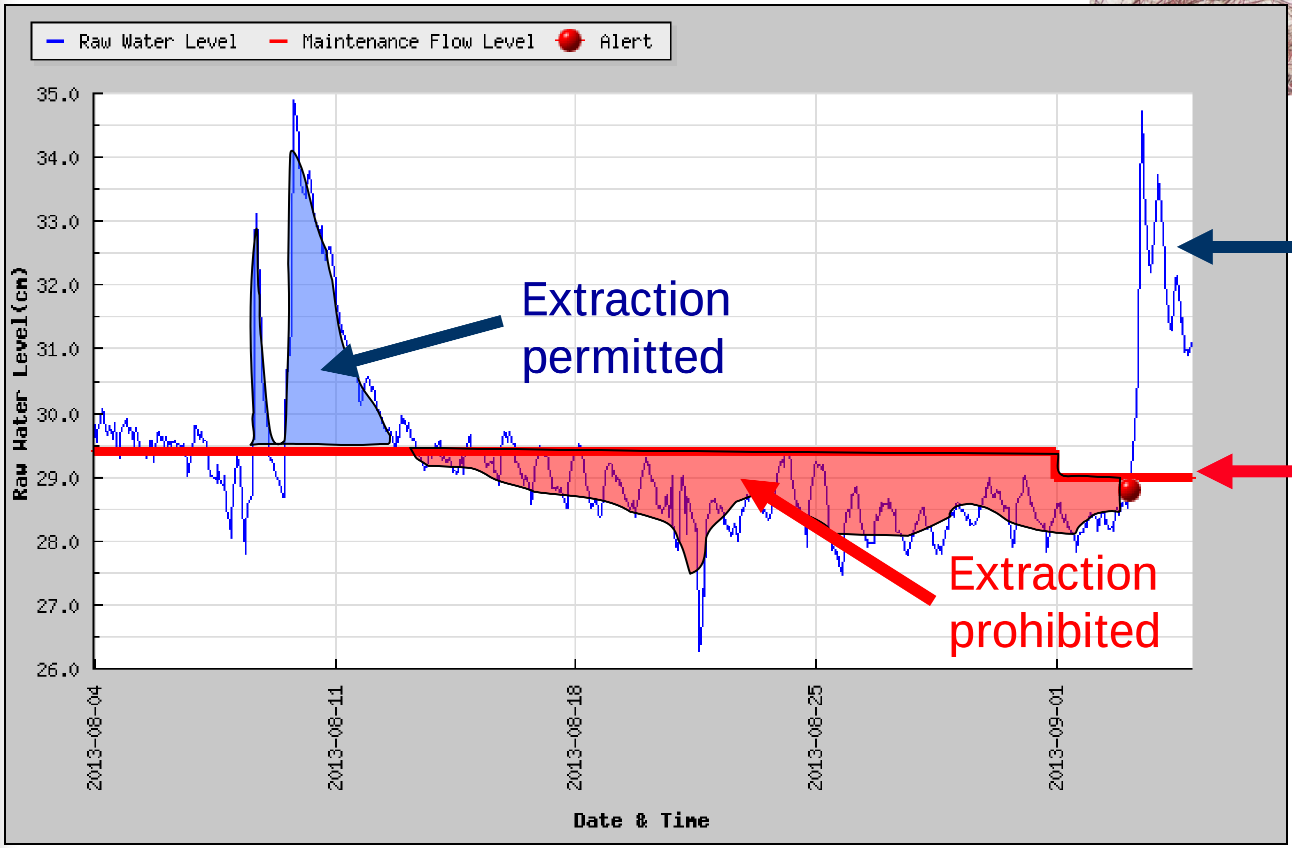
Background: Availability of Surface Water

- PEI's fresh water surface bodies are relatively short, with a significant portion of rivers being estuarine in nature, and there few natural lakes or ponds (Environment Canada – PEI DOE, 1991).

- It is well documented that stream flow is highly variable throughout the year, and that groundwater discharge comprises some two thirds of annual stream flow, but may constitute 100% of stream flow during summer and early fall.(Environment Canada – PEI DOE, 1991)(Francis, 1989, Environment Canada – PEI DOE, 1991 , etc.)

- Excessive pumping of water directly from a stream results in instantaneous reductions in stream flow and on aquatic habitat and there is a direct correlation between withdrawal rate and stream flow.
  - (This contrasts with groundwater withdrawals, that impact baseflow over a larger area, but at a more gradual rate, as some portion of the water is coming from annual storage that has accumulated over comparatively longer time frames).

Managing Surface Water Withdrawals



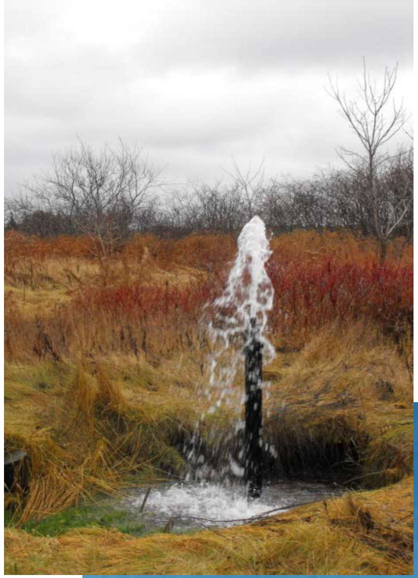
Availability of Groundwater

- Key source of water for most use in the Province
  - Stable and predictable source of water
  - Not highly sensitive to short term weather patterns

- Useable quantities of groundwater can be found virtually anywhere in the Province

- Annual recharge rates in PEI are high
  - ~ 385,000 m3 per km2 /yr
  - 154 Olympic pools per km2 /yr
  - Amount of used by a community of 5000 in each km2
  - 70 times higher than currently used

- Groundwater Permitting Criteria
  - Extraction not to reduce average summer stream base flow more than 35%
  - Currently use 7% of amount available by the policy
  - Watershed specific base flow utilized in permitting provides for unique number in each watershed



Background: Availability of Groundwater

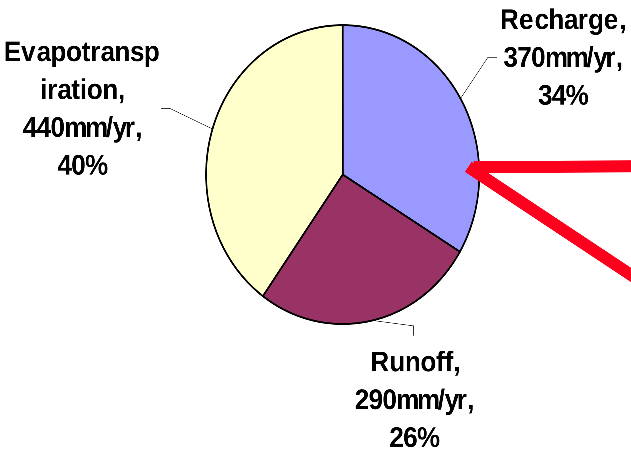
- Groundwater recharge rates in PEI are relatively high (JWA / P Lane Associates 1990, Rivard et al. 2013) compared with many other jurisdictions in Canada (Rivard et al. 2013), averaging around 35% of annual precipitation ...or around 400 mm year (Francis, 1989, Jiang et al 2004, Vigneault et al, 2007, Rivard et al, 2013)

- Estimates of total quantity of renewable groundwater (ie recharge) and the proportion that is actually extracted can be made:
  - For recharge: by multiplying the amount of precipitation, recharge rate, and areal extent of the aquifer
  - For estimates of groundwater extracted: derived from population data and departmental records for Groundwater Extraction permits (Somers and Savard 2008, Li, 2013).

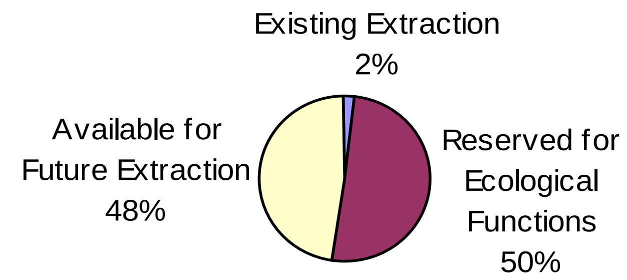
- Estimates for the proportion of water extracted as a percentage of the quantity available under the Water Extraction Policy are made by assuming all but 35% of total recharge is left to sustain stream flow (Li, 2013)

Background: Availability of Groundwater Under Historical and Current Regulatory Regimes

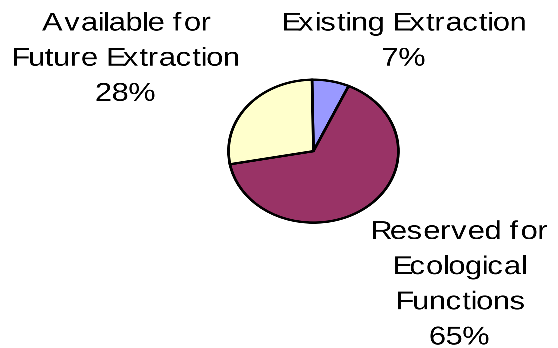
PEI hydrologic cycle



Historical Regulatory Regime



Current Regulatory Regime



- **To maintain groundwater resources, the rate of extraction should not exceed the rate of groundwater recharge.**
- **Historically groundwater extraction was limited to only 50% of recharge, leaving a significant safety margin for groundwater resources, and with the remaining portion or recharge available to help support ecological functions (stream-flow).**
- **The Current policy has the effect of increasing the amount of protection to aquatic ecosystems, while still leaving significant amounts of groundwater available for extraction.**

Regional Variability

- While the general geology, physiography and hydrology of the Province is relatively similar, there are some regional differences:
  - Stream flow in some western rivers and streams is "flashier" and on average, well yields in western PEI tend to be lower
  - Groundwater recharge rates and the nature of groundwater – surface water interaction likely differ somewhat by region
  - Even on a local scale hydrogeological conditions can vary significantly
- As a result of these factors, impact of withdrawals must be:
  - Assessed on the basis of site specific conditions
  - Verified by data

Watershed Yield (baseflow)

Stream Gauge Location	Gauge Station Watershed Area (km^2)	Summer Baseflow Yield ($m^3/d/km^2$)
Mill R.	46	361
Wilmot R.	49	717
Dunk R.	114	849
West R.	70	903
Bear R.	15	553

Background : Regional Variability and local differences in watershed yield

- Regional variability of the Province's geology is slight compared with most other jurisdictions (Rivard et al, 2013) but is reflected in different proportions of more permeable sandstone vs. less permeable strata such as claystone. These differences are described in greatest detail by mapping by van de Poll (1983)

- Differences in hydrogeology and stream flow regimes are described in Francis (1983) and Environment Canada – PEI Dept. of the Environment (1991)

Moratorium

- Established by Executive Council in February 2002
- Only on new high capacity wells for agricultural irrigation

The End

Questions?

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