Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures

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Outline

- Background and study need
- Study steps and approach
- Results
- Conclusion and insights

Need for Study

- This study is in response to the Commission's request to model and evaluate the health consequences of a severe nuclear accident to address concerns raised during public hearings on the environmental assessment (EA) for the Darlington Nuclear Generating Station refurbishment project, and to update the Commission accordingly
- The study was completed and published in 2015.

Being prepared in the event of an emergency is an essential part of being a responsible nuclear regulator

Study Steps

- Identify and model a generic large release (GLR) that is a consequence of a hypothetical severe accident
- Estimate the doses associated with and without protective actions applied (e.g., evacuation)
- Determine human health and other consequences

Selection of Source Term

- The “source term” is defined as the types and amounts of radioactive or hazardous material released to the environment following an accident

- For this study, a generic source term was derived based on the CNSC’s large release safety goal of 1 x 10^{14} Becquerel (Bq) of cesium-137 (*CNSC-REG-DOC- 2.5.2 : Design of reactor Facilities Nuclear Power Plants, 2014*)

- This source term is greater in magnitude than source term previously assessed in Darlington Refurbishment EA with a probability of occurring of 3.7 x 10-7 (3.7 in 10 million).

Hypothetical Scenarios Analyzed

- 3 scenarios considered for a generic large release of 1E+14 Bq of Cs-137.
  - 24-01: Accident progresses for 24 hours followed with a short 1 hour release
  - 24-24: Accident progresses for 24 hours followed with a 24 hour release
  - 24-72: Accident progresses for 24 hours followed with a 72 hour release

- Sensitivity cases: to examine the potential effects of an even greater hypothetical release,
  - a four-fold increase (x4) in the quantity of radionuclides released for the latter two scenarios (**24-24x4** and **24-72x4**) to be comparable to a multi-unit accident

Key Assumptions: General

- Assumed releases – containment and vacuum building functioning as designed; however, no credit for emergency mitigating equipment or operator actions
- Constant wind speed and direction for short-term release (24-01 scenario), variable wind speed and direction for medium- to long-term releases (the remainder of the scenarios).

Key Assumptions: Protective Actions

- Evacuation
  - 100% effective (individuals evacuated received zero dose)
- Sheltering
  - 20% dose reduction for those sheltered
- Thyroid blocking (Potassium iodine (KI) pill ingestion)
  - 100% effective for those who took KI (assumed it was taken as directed)

Human Health Risk Assessment

- Population-weighted dose was used to generate the risk to the majority of the population that would be affected by the accident.
  - both average and maximum (95th percentile) population-weighted doses used as inputs
  - 30 year old male used as a representative of adult population
  - 4 year old female used as a representative of child population

- Consistent with international practice :
  - quantitative examination to determine increased risks for different types of cancer - all cancers combined, leukemia, thyroid cancer (adults and children)
  - used a Radiation Risk Assessment Tool (RadRAT)

Results: Human Health

- Nearly impossible to distinguish most radiation-induced cancers from baseline cancers (see figure: 6.1)

- Childhood thyroid cancer is the only radiation-induced cancer that could be distinguished from baseline cancers (see figures: 6.7 and 6.8)
  - for the most severe scenario where the radiological release was increased four-fold, the risk was predicted to be an additional 0.3% in developing childhood thyroid cancer (fig 6.8)
  - this is in addition to an approximately 1% baseline future risk of developing childhood thyroid cancer in close proximity to the plant (12 km) was predicted (fig. 6.7).

Consideration of sensitive receptors, such as children, is an important aspect of emergency planning

Figure 6.1: Predicted impact on risk of developing cancer (all combined)

24 hour hold-up, followed by a 1 hour release (24-01)

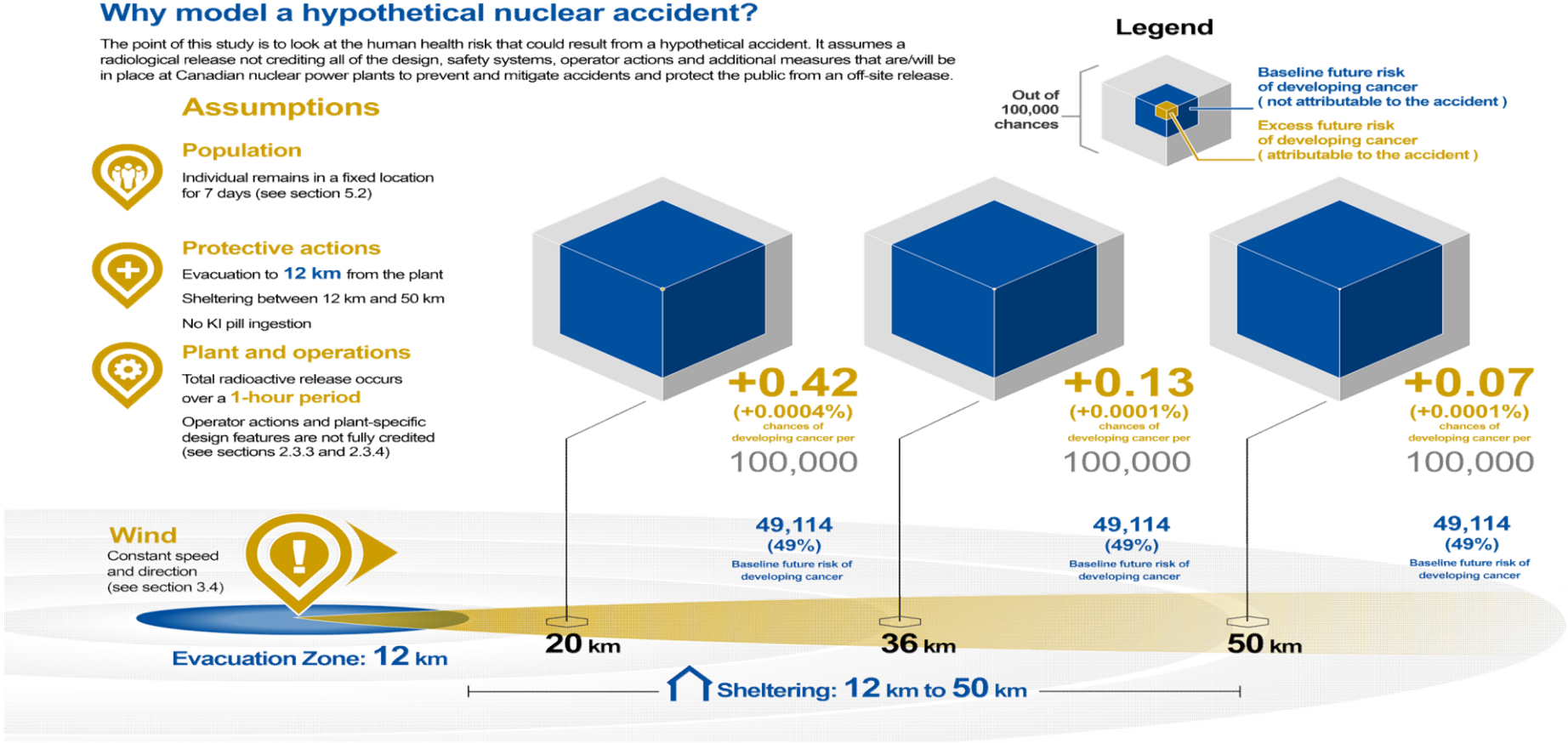


Figure 5.1: Predicted impact on risk of developing enhanced thyroid cancer

24 hour hold-up, followed by a 1 hour release (24-01)

Why model a hypothetical nuclear accident?

The point of this study is to look at the human health risk that could result from a hypothetical accident. It assumes a radiological release regardless of the design, safety systems, operator actions and additional measures that are actually in place at Canadian nuclear power plants to prevent and mitigate accidents and protect the public from an off-site release.

Assumptions

Population

Individual remains in a fixed location for 7 days (see section 5.2)

Protective actions

Evacuation to **12 km** from the plant

Sheltering between 20 km and 50 km

No KI pill ingestion

Plant and operations

Total radioactive release occurs over a **1-hour period**

No operator actions credited (see section 2.3.3)

No plant-specific design features credited (see section 2.3.4)

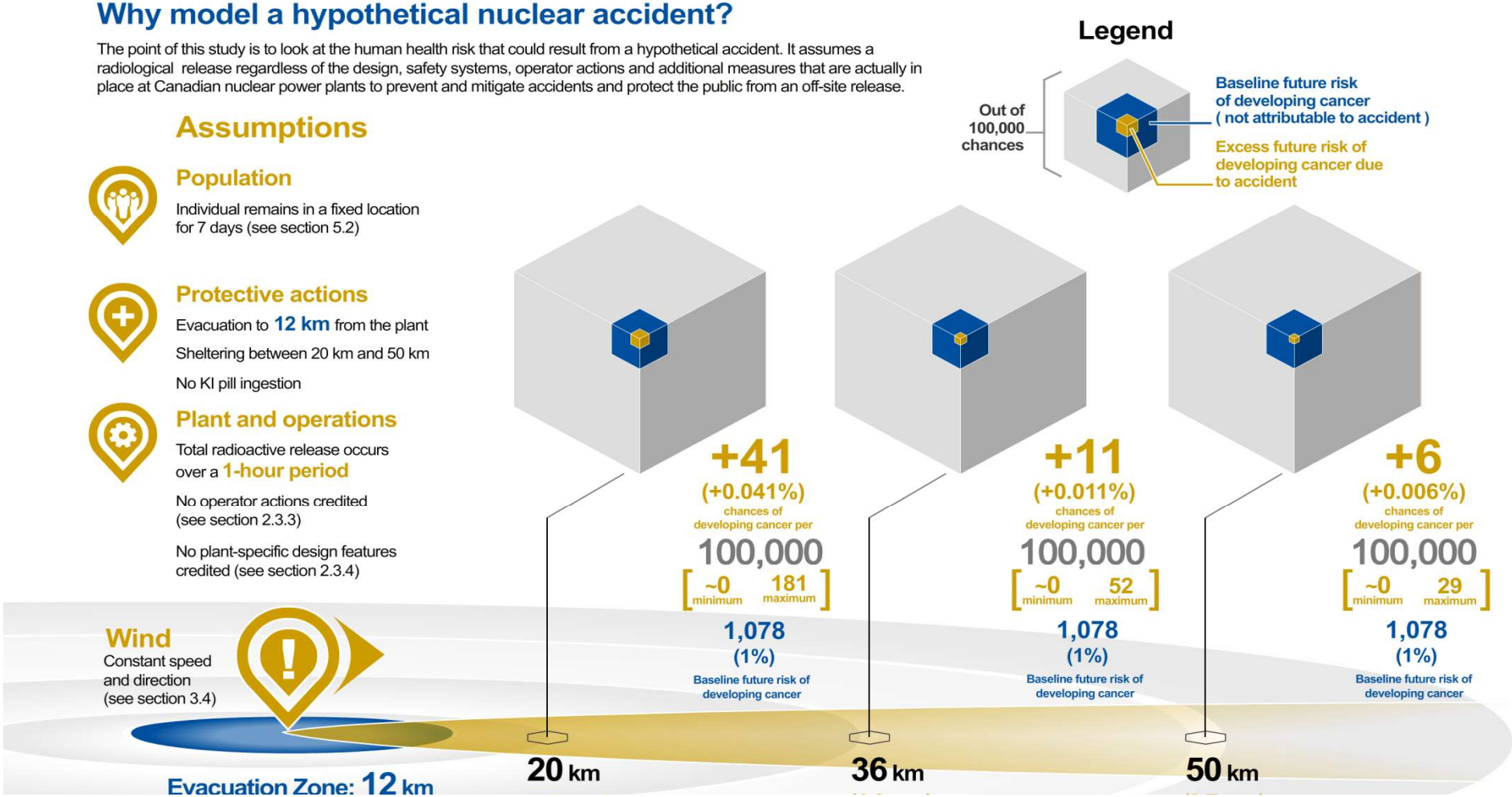
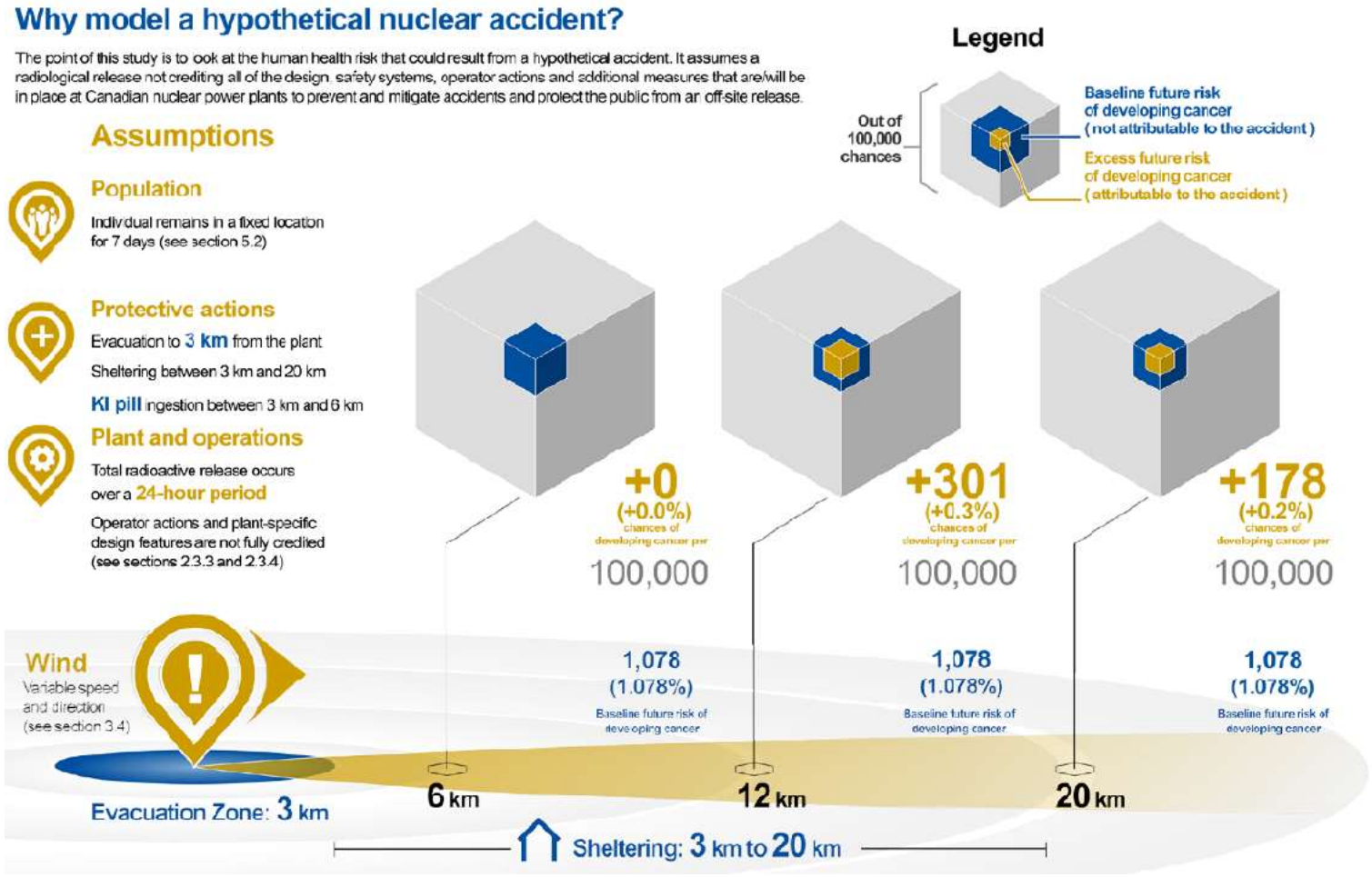


Figure 6.8: Predicted impact on risk of developing childhood thyroid cancer

24 hour hold-up, followed by a 24 hour release, factor of 4 radiation increase (24-24x4)



Framing the Human Health Results

- The childhood cancer risk finding is not unexpected given the radiosensitivity of a child's thyroid gland
  - this is consistent with what actually happened following the Chernobyl accident
- Risk is likely overestimated as it is based on modelled dose, rather than measurements

Risk is likely overestimated as a result of conservative assumptions

Conclusion and Study Insights

- No detectable increased risk related to all cancers combined, leukemia and adult thyroid cancer. The only result: increased risk of childhood thyroid cancer.
- The theoretical increased childhood thyroid cancer risk findings suggest that further consideration is needed in how sensitive receptors (i.e., children) are considered in emergency planning, such as plans for KI pill distribution and administration.

Emergency response is flexible and would be implemented according to the potential risk

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