# Hazard Resilience Index (HRI)

## *Geological Hazards*

## *(related to soil and earth)*



## Geological Hazards

Please refer to the *Hazard Resilience Index Instructions (HRI)* document for more information on using this document.

***In order to avoid repetition, resiliency factors that only apply to human-caused hazards are in italics.***

## Debris Avalanches, Debris Flows and Torrents – Natural and Human

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Community officials and residents check frequently with weather forecasting agencies such as Environment Canada and have experts monitor conditions and issue warnings related to major events that may trigger debris flows, such as frequent rolling stones or the presence of erodible material in the debris-flow source-areas in combination with heavy precipitation. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based debris avalanche, flow and torrent exercises have taken place in the community-at-large (e.g., table-top or full-scale exercises). | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has implemented appropriate strategies to reduce debris hazards by stabilizing slopes to reduce erosion using drainage systems, soil bio-engineering (the use of living plant materials to perform engineering feats), reforestation or installing sills and ramps in stream beds or constructing dams. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has implemented appropriate strategies to reduce debris hazards by using structural measures to redirect, slow, or retain debris flows such as debris flow breakers, drop structures (to assist with flow control), debris rakes, retention basins, deflection structures, transport channels, or tunnels. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has in place a means to consult with Traditional Knowledge holders to develop appropriate structures and strategies to reduce debris flow and other mass movements. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has regulations that prohibit development, limit land use, or require structural reinforcements for buildings that must remain in the debris hazard areas, such as reinforced walls and safe interior spaces. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has prohibited human activity in areas which pose a high risk of debris avalanches, flows and torrents and enforces this. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify community residents of a potential debris avalanche, flow and torrent, including clear signage of evacuation routes and response plans. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify emergency response personnel of a potential debris avalanche, flow and torrent. | ☐ |

## Dust and Sand Storms

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Community officials check regularly with weather and air quality monitoring agencies such as Environment Canada to anticipate dust and sand storms generated locally or generated elsewhere that may blow into the community in order to issue appropriate warnings. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based dust and sand storm exercises have taken place in the community-at-large (e.g., table-top or full-scale exercises). | ☐ |
| ☐ | ☐ | ☐ | ☐ | Farmers minimize deep tillage in areas susceptible to dust and sand storms. | ☐ |
| ☐ | ☐ | ☐ | ☐ | If the dust and sand storms are severe or persist for an extended period, the community has plans to evacuate residents (especially those with respiratory diseases) to a designated shelter with dust-free air. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent dust and sand storms communities have implemented appropriate strategies to reduce erosion, deposition (collection of dirt deposits) and desertification including: re-vegetation of eroded areas with trees, shrubs or grasses that are indigenous to the area; stabilization of dunes and slopes with branches or other materials pushed into the sand in a grid pattern; and establishment of wind breaks to control wind erosion*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent dust and sand storms*, *communities limit businesses that use significant amounts of water (such as agricultural irrigation and houses with gardens that require large inputs of water) in areas susceptible to drought and desertification; where community gardens are present, use of drought resistant or low water-demand plants is encouraged along with the application of organic materials to maintain soil fertility or other appropriate urban landscaping practices*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent local dust and sand storms*, *communities have regulations that require farmers to, and limit land uses that, remove or alter vegetation (e.g., over-cultivation of agriculture, livestock over-grazing) or that require planting of vegetation on lands susceptible to wind erosion and desertification*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify emergency response personnel of potential dust and sand storms. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify residents of dust and sand storms and to advise them to seek stable shelter for all family members and to shelter domesticated animals/pets; community response plans provide public shelters and make them available during dust/sand storms. | ☐ |
| ☐ | ☐ | ☐ | ☐ | When dust and sand storms are forecast, the community and power company have a shared plan in place to coordinate the shut off community electrical power to non-essential regions of the grid to avoid electrical fires (electricity to medical facilities, law enforcement and government should be maintained and backup generators in place). | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has in place a means to consult with Traditional Knowledge holders about dust/sand storms and traditional mitigation, response and warning systems. | ☐ |

## Erosion, Deposition (collection of dirt deposits) and Desertification

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Community officials check frequently with weather forecasting agencies such as Environment Canada to anticipate dry weather and wind storms that may cause wind erosion, dust and sand storms in order to issue warnings. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community has completed mapping of areas susceptible to erosion, deposition and desertification and shared the maps with community members. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based discussions have taken place in the community-at-large (e.g., table-top or full-scale exercises) regarding erosion, deposition (collection of dirt deposits) and desertification. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent local erosion, deposition (collection of dirt deposits) and desertification, communities have regulations that limit land uses that remove or alter vegetation (e.g., over-cultivation of agriculture, livestock over-grazing) or that require planting of vegetation on lands susceptible to wind erosion and desertification*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent local erosion, deposition (collection of dirt deposits) and desertification, communities limit activities that use significant amounts of water (such as resource extraction/mining and houses with gardens that require large inputs of water) in areas susceptible to drought and desertification, including in community gardens*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In order to prevent local erosion, deposition (collection of dirt deposits) and desertification, communities implement appropriate strategies to reduce erosion, deposition (collection of dirt deposits) and desertification including: re-vegetation of eroded areas with trees, shrubs or grasses that are indigenous to the area; stabilization of dunes and slopes with branches or other materials pushed into the sand in a grid pattern; and establishment of wind breaks to control wind erosion, particularly in mining sites after closure*. | ☐ |

## Expansive Soils

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Community-based discussions have taken place in the community-at-large regarding the potential for expansive soils, including specific consultation with Traditional Knowledge holders. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community has completed mapping of areas susceptible to expansive | ☐ |

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| | | | | soils and shared the maps with community members. | |
| ☐ | ☐ | ☐ | ☐ | *Most residents living in areas with expansive soils have been educated about these hazards and know that structures built on expansive soils can be better protected if water does not infiltrate soils next to the foundation. This can be prevented by: maintaining soil sloping away from the building; placing gardens, grasses and trees requiring watering away from the building; and ensuring swimming pools and pipes do not leak moisture into soils near the foundation*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has geo-technical engineers (experts in soil behavior and earth materials) regularly inspect and monitor areas susceptible to expansive soils. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *The community requires new developments to have land checked by geo-technical engineers for expansive soils and if present*, *the community has regulations that limit construction or require engineering techniques to prevent building foundation damage, such as building foundations beneath the zone of water content fluctuation and adding non expansive materials to the soil; existing structures affected by these expansive soils (e.g., adjacent properties) are updated to meet equal standards*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has a means to consult with Traditional Knowledge holders about the presence of expansive soils within the community to help with community planning. | ☐ |

## Gravitational Mass Movements (Landslides)

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Communities have regulations that prohibit development, limit land use, or require appropriate hillside development practices for buildings located in landslide hazard areas (which have been identified and mapped), such as grading slopes to reduce steepness, using structural systems to increase slope resistance, or dewatering and redirecting drainage. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *Communities work with utility companies to ensure that underground wiring or culverts do not lead to an increased risk of landslides down slope*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based landslide exercises have taken place in the community-at-large (e.g., table-top or full-scale exercises). | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In developed areas subject to slope instability, communities and landowners have implemented appropriate strategies to reduce landslide hazards by: directing surface and groundwater away from landslide areas; keeping or planting vegetation on slopes to stabilize soils; installing retaining walls to stabilize slopes*. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In developed areas subject to slope instability, communities have used structural measures to redirect, or retain landslides away from roads and developments such as retention basins, deflection structures, or tunnels.* | ☐ |
| ☐ | ☐ | ☐ | ☐ | *Most residents living in high-risk landslide areas have been educated about landslide hazards and high risk areas and know to avoid* | ☐ |

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| | | | | *performing activities that can trigger landslide, such as blasting or slope alteration; maintaining soil sloping downhill; placing gardens, grasses and trees requiring watering away from slopes; and ensuring swimming pools and pipes do not leak moisture into slope soils*. | |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify emergency response personnel of potential landslides. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify residents of potential landslides, including evacuation route signage in multiple languages and an effective alert system (e.g., horn/siren or social media notification). | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has a local Search and Rescue (SAR) team of volunteers in the community or nearby that is trained and involved in emergency response activities. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify local professional Search and Rescue (SAR) team and volunteers of potential landslides. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a means through which Traditional Knowledge holders engage with decision makers to make plans and develop evacuation routes based on historical knowledge of landslide events. | ☐ |

## Land Subsidence and Sinkholes

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
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| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Communities have regulations that prohibit development, limit land use, or require development buffers in areas susceptible for land subsidence or sinkholes. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community members have been educated about subsidence and sinkhole hazards and high risk areas to encourage voluntary land use restrictions and support for hazard mitigation planning. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community monitors check regularly with geologists and monitor areas at risk of land subsidence and sinkholes. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based land subsidence and sinkhole exercises have taken place in the community-at-large (e.g., table-top or full-scale exercises) | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In areas subject to subsidence and sinkhole risk, communities require or appropriate strategies to reduce hazards by: limiting rainwater infiltration by directing runoff and/or making ground surfaces impermeable; using flexible pipes; and preventing the decline of the water table.* | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community has a local Search and Rescue (SAR) team of volunteers in the community or nearby that is trained and involved in emergency response activities. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify Search and Rescue (SAR) volunteers of potential sinkholes or land subsidence events. | ☐ |
| ☐ | ☐ | ☐ | ☐ | The community consults Traditional Knowledge holders about past sinkholes and land subsidence events to aid in community and emergency planning. | ☐ |
| ☐ | ☐ | ☐ | ☐ | *In areas subject to subsidence and sinkhole risk, communities require appropriate strategies for erosion and sedimentation control such as* | ☐ |

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| | | | | *using special building foundations; reinforcing road and railway infrastructure; and limiting further development through covenants, easements or land purchase; existing structures affected by these subsidence areas or sinkholes (e.g., adjacent properties) are updated to meet equal standards.* | |
| ☐ | ☐ | ☐ | ☐ | Prior to issuing building or road permits, communities require professional engineering/environmental experts conduct an assessment to identify existing and potential subsidence and sinkhole areas. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify emergency response personnel of potential sinkholes or land subsidence. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify residents of potential sinkholes or land subsidence. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Communities have completed mapping of areas susceptible to sinkholes and land subsidence and shared the maps with community. | ☐ |

## Submarine Slides

| **Hazard Resilience Rating** | High Resilience ☐ | Low Resilience ☐ | Need More Info ☐ | Not Applicable ☐ |
|---|---|---|---|---|

| Yes | No | Need More Info | Not Applicable | FACTORS | This factor is important to my community |
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| ☐ | ☐ | ☐ | ☐ | Communities have completed underwater mapping of areas susceptible to submarine slides and have shared the maps with community, fishers and trappers. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Community-based coastal surge exercises associated with submarine slides have taken place in the community-at-large (e.g., table-top or full-scale exercises). | ☐ |
| ☐ | ☐ | ☐ | ☐ | Dredging has taken place to avert potential submarine slides and/or dredging activities are monitored and assessed for their potential to cause submarine slides. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Evacuation routes from coastal surges associated with submarine slide are marked with visible signage in multiple languages (e.g., English/French/Aboriginal languages). | ☐ |
| ☐ | ☐ | ☐ | ☐ | Plans are in place to develop and preserve coastal forests that act as protection against coastal surges associated with submarine slides. | ☐ |
| ☐ | ☐ | ☐ | ☐ | Residents are educated about submarine slides and associated coastal surges and know how and where to evacuate. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify emergency response personnel of potential submarine slides and areas at risk of surge. | ☐ |
| ☐ | ☐ | ☐ | ☐ | There is a warning system in place to notify residents of potential submarine slides and areas at risk of associated surge. | ☐ |

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