s) existing or potential fish and wildlife use, aquatic riparian habitat;
t) how to prevent the spread or colonization of invasive species, if applicable; and
u) site accessibility for machinery and other equipment, as needed.

Notes:
1) *See CAN/BNQ 2501-500.*
2) *See TAC 2010.*

7.2.2 Qualitative risk assessment

A qualitative risk assessment shall be carried out to determine the likelihood of channel erosion and sedimentation, and a qualitative level of risks associated with the findings from Clause 7.2.1 at the project site shall be determined. In addition, a hydrology study shall also be completed to support this assessment, as well as to provide flows to analyze for hydraulic calculations and erosion potential. Availability of historical flow data in northern regions are generally limited such that regional hydrological analysis or climate-based assessments are often required to supplement local data. Additional information about hydrology can often be obtained through local and traditional knowledge. It is further noted that extreme flood events in northern climates can be unpredictable due to changing environmental conditions, for example, permafrost degradation altering run-off patterns. Significant uncertainty in flood flows will generally exist in such assessments. A conservative risk assessment supported by design criteria with added safety margins shall be applied in such cases.

7.3 Planning and design

7.3.1 General

Proper planning, siting, and design of open channel infrastructure to account for erosion and sedimentation risks requires

a) a basic understanding of drainage patterns, fluvial geomorphology, and of the hydrological regime of the particular watercourse;
b) an understanding of the potential or proven presence of ice-rich permafrost, sediment transport, and erosion/sedimentation processes;
c) historical information of channel morphology from the community, territorial or provincial government, federal government, scientific literature, or other sources;
d) appreciation for the uncertainty associated with the prediction of scour depths;
e) understanding that siting infrastructure immediately landward of a regulatory watercourse setback line (where applicable in various regulatory jurisdictions) does not guarantee the infrastructure will be safe from erosion hazards; and
f) appreciation for how diverse types of human interventions to mitigate or respond to erosion and sedimentation can impact the environment and erosion/sedimentation in adjacent areas.

7.3.2 Strategies to address erosion and sedimentation in open-channel environments

7.3.2.1 Strategies

Strategies for responding to open channel erosion and sedimentation can apply to existing infrastructure as well as proposed infrastructure and can generally be grouped as follows (adapted from BC MoE 2013):

a) Do nothing or business as usual – this is not usually a viable long-term strategy in areas where open-channel erosion or sedimentation issues are problematic, but represents an important strategic option to consider as a benchmark or baseline scenario for comparing the consequences, costs, and benefits of other strategic response options.

b) Monitoring before taking corrective actions – monitoring can be an adequate short-term solution in areas where open-channel erosion or sedimentation is not immediately threatening infrastructure, people, or the environment. Monitoring of the progress of erosion and sedimentation, at a frequency to be determined by the QP, can provide important information to assess how the situation will likely evolve and help determine the most appropriate management strategy. An assessment of potential corrective actions shall be completed at the same time as monitoring occurs, in order to be pro-active if erosion and sedimentation progresses at a faster rate than predicted.
c) Protect or hold the line – a reactive strategy to protect people, property and infrastructure, which typically involves the use of structural measures such as bank protection, berms, dikes, diversions, soft engineering techniques, etc. This has been the traditional response to erosion on Canadian rivers and streams, but sometimes can be seen as a short-term solution with potentially negative long-term consequences at some sites, due to on-going river dynamics and geomorphological changes. Such a strategy has to take into consideration potential future changes in the river or stream morphology in response to the placement of structural measures.
d) Accommodate – an adaptive strategy that allows continued occupation of areas in vicinity of open-channel environments while changes are made to human activities or infrastructure to adapt to open-channel erosion and sedimentation processes.
e) Managed retreat or managed realignment – a strategic decision to withdraw, relocate, or abandon infrastructure at risk due to open-channel erosion (or related flood) hazards. This strategy becomes more difficult in densely-populated areas and is typically undertaken with a long-term perspective. It can, however, sometimes be the preferred solution in northern regions where highly dynamic rivers could further threaten infrastructure in the vicinity of open-channel environments.
f) Avoid – management of development to direct it towards areas where existing and future open-channel erosion hazards are low. This might involve the use of setback lines or identification of “no build” zones.

7.3.2.2 Strategic planning

These strategies can be combined and adapted over time to respond to changes in climate, new data, infrastructure demands, community needs, and/or changing erosion and sedimentation processes. The strategic planning process shall involve the following steps:

a) identify problems and opportunities related to open-channel erosion and sedimentation;
b) identify stakeholder and community needs and objectives;
c) assess the consequences of a “do nothing” or “business as usual” approach;
d) formulate alternative strategies;
e) evaluate consequences of alternative strategies (e.g., multi-criteria or cost-benefit analysis);
f) compare alternative strategies; and
g) select preferred strategy or strategies for managing and mitigating erosion and sedimentation risks.

Stakeholder engagement shall occur throughout the planning process to include consideration of the needs and interests of affected parties.

7.4 Structural measures

The design and construction of structural measures for erosion and sedimentation management in open-channel environments in the North shall consider permafrost issues. In addition, in open channel environments, thalweg management shall be considered when designing and implementing structural measures that could lead to scour. For complex systems, fluvial analysis of thermal erosion processes shall be considered to support the design of structural measures (Randriamazaoro et al. 2007). With due consideration to site-specific conditions and processes, and design criteria (including design life), the following ESC measures shall be considered as possible appropriate responses to erosion at infrastructure sites in northern open-channel settings:

a) Dikes or berms – used to limit surface water runoff in areas susceptible to erosion. These can be armoured if required for long-term resistance against erosion, or merely tarped, especially for temporary installations; for example, if they are used to limit runoff from stockpiles.

b) Diversions – man-made channels built to route excess water away from an existing path in order to mitigate the effects of flooding and erosion; or during construction. Water shall not be routed onto or into terrain where ice-rich permafrost is present.

c) Retaining walls – used to support and tie back slopes or fill soils, either as part of the design of the infrastructure (e.g., a building, bridge abutments or roads), or to reduce the likelihood of a slope failure and consequent release of sediment that can then erode and deposit elsewhere. Retaining walls also serve to reduce upslope gradients, thus reducing water velocity and erosion. Retaining walls can be as simple as timber cribs or gabions or bin walls (local conditions and material availability permitting), or as complex as mechanically stabilized earth walls with concrete panels.

d) Buttresses – used to support slopes; can allow steeper cutslopes or fillslopes along roads while protecting the slopes from sloughing and erosion, and sometimes mitigating permafrost thaw. Buttresses are usually made of large angular rock that also serves as riprap.

e) Revetments – cladding structures to protect slopes from erosion, often consisting of armour stone or rock, gravel bags, geotextiles, and geomattresses. Depending on the application, these options could be considered for short- or long-term protection measures.

   Note: *Solutions such as sand bags or gravel bags are likely to be very short-lived, but could also temporarily replace lost sediment when they fail.*

f) Groynes or spurs – narrow structures, usually straight and perpendicular to the pre-project shoreline. The effect of a single groyne is the accretion of shoreline material on the updrift side and erosion on the downdrift side. Groynes are built to reduce erosion in river systems, either to stabilize a stretch of bank or to divert flow away from areas prone to erosion. Potential negative effects include flow constriction in rivers resulting in higher velocities and increasing bed erosion.

g) Energy mitigation structures – structures that reduce the energy in a channel and thus reduce erosive effects, for example, structures that reduce the energy of water released from high-head hydropower plants. These structures can include drop structures, riffles and baffles, or detention basins, as applicable according to permafrost presence or characteristics. Such structures can also have secondary benefits, such as improving fish passage.

h) Soft-engineering techniques – nature-based solutions including bio-engineering, slope stabilization and disturbed-surface stabilization using mulches and matting, and other revegetation techniques. Using minimally intrusive, natural, and local materials able to accommodate the natural riverine processes (e.g., ferry landings).

i) Thermosyphons or thermoprobes – to protect a site from permafrost thaw, including natural or man-made slopes (e.g., bridge abutments or approaches on warm permafrost). This expensive solution may be considered to protect critical infrastructure and can have the added benefit of reducing the likelihood of erosion and sedimentation from a slope failure. A thermosyphon or thermoprobe system could also be integrated with simple methods to reduce or prevent solar radiation reaching the site, for example, via a system of reflectors in the area to be cooled (Ravens and Ulmgren 2019). Other strategies could also be applicable, as demonstrated by a series of permafrost test sections along the Alaska Highway, Yukon, including air convection embankments, light-coloured aggregate, longitudinal culverts, and snow/sun sheds (Malenfant-Lepage et al. 2012).

Notes:

1) *Further research would be required to determine the feasibility of thermal mitigations for challenging environments such as the Duval River in Pangnirtung, Nunavut (Clause 4.4). While thermal mitigations would be unlikely to provide a standalone solution for such cases, they could potentially form part of an integrated solution.*
2) *See GNWT DOT 2013 for more information on the different types of structural measures potentially applicable in open-channel environments.*

There is also considerable overlap in the strategies for erosion and sedimentation mitigation in each environment that do not necessarily entail physical structures. Strategies and best management practices for the terrestrial-based portions of coastal and lakeshore, open-channel, and terrestrial mitigations are provided in Clauses 8 and 9.

8 Erosion and sedimentation management for terrestrial environments

8.1 General

The main objectives of an erosion and sedimentation risk management strategy for terrestrial project sites, likely including an ESCP, are to preserve permafrost or mitigate the effects of permafrost thaw, mitigate the loss of soil during construction, protect stockpiled topsoil, prevent sedimentation of storm water and receiving streams, and prevent pollution of the air with dust and particulate matter. The process of creating an appropriate ESCP shall include, but not be limited to, the following elements:

a) a site-specific evaluation of existing conditions, including an assessment of risk;
b) planning and design, incorporating a summary of proposed conditions at completion of construction;
c) a description of the placement of proposed erosion and sedimentation mitigations, including construction sequencing;
d) maintenance requirements; and
e) environmental procedures to be followed during the work.

The procedures specified in Clauses 8.2 to 8.4 and Clauses 9 through 11 describe the above-listed elements and incorporate northern and other relevant guidelines to be applied to the conditions anticipated at the project site. For sites where the site conditions include coastal and lakeshore considerations and/or open-channel considerations, Clauses 6 and/or 7 will also be of use.

8.2 Site-specific evaluation and risk assessment

A site-specific evaluation carried out by a qualified geotechnical engineer, or engineering team, shall determine and describe the following:

a) permafrost, including active layer thickness, ground temperature, ice content, massive ice (wedges or lenses), soil porewater salinity, and other features of note;
b) soil and bedrock types, including grain size characteristics, soil moisture contents, and plasticity, if applicable (TAC 2010). Depending on the findings from standard testing for the purposes of soil classification and determination of relevant engineering properties, the requirement for other possible testing shall be considered to further define the erosion and sedimentation potential of *in situ* or proposed imported materials;
c) groundwater (seasonal or perennial);

d) slope gradients and terrain or topographical features of note that might affect surface water drainage or indicate the existence or potential for slope and/or permafrost processes or instabilities;
e) existing site surface conditions including vegetation, existing structures, or other features;
f) existing site services, including surface water drainage infrastructure, if any;
g) proximity to water bodies (fish-bearing waters, ephemeral or perennial streams, ponds, lakes, or other water bodies, etc.);
h) proximity to protected eco-types or other valued receptors (wildlife habitat, areas of cultural importance, etc.); and
i) proximity and/or similarity to sites experiencing thermal or hydraulic erosion issues, or, conversely, sites that are performing well (CSA PLUS 4011).

Notes:
1) *See CAN/BNQ 2501-500.*
2) *See TAC 2010.*

A qualitative risk assessment shall be carried out to determine the likelihood of erosion and sedimentation, and a qualitative level of risks associated with the above-listed findings at the project site.

8.3 Planning and design

8.3.1 General

Proper planning, siting, and design of terrestrial infrastructure to account for erosion and sedimentation risks requires
a) a basic understanding of geohazards, including the potential or proven presence of ice-rich permafrost, sediment transport, and erosion/sedimentation processes;
b) erosion rate information from the community, territorial or provincial government, federal government, scientific literature, analysis of air photo and mapping information obtained at specified time intervals (e.g., 10- or 20-year intervals), field and laboratory work, or other sources;
c) recognition of the uncertainty associated with the prediction of potential erosion and sedimentation events, as related to weather events (extreme or not), geohazards (e.g., mass-wasting events), or human interventions or lack thereof;
d) appreciation for the uncertainty associated with the prediction of the future behaviour of permafrost, and the natural or anthropogenic processes that could change that behaviour, whether or not the characteristics of the permafrost are associated with other geohazards, e.g., unstable slopes;
e) consideration of monitoring in areas where the solution is not immediately obvious, and erosion or sedimentation is not immediately threatening infrastructure, people, or the environment. Monitoring of the progress of erosion and sedimentation, at a frequency to be determined by the QP, can provide important information to assess how the situation will likely evolve and help determine the most appropriate management strategy. An assessment of potential corrective actions shall be completed at the same time as monitoring occurs, in order to be proactive if erosion and sedimentation progresses at a faster rate than predicted;
f) understanding that siting infrastructure on the “safe” side of a regulatory setback line (where applicable or available in various regulatory jurisdictions) does not guarantee the infrastructure will be safe from erosion hazards; and
g) appreciation for how diverse types of human interventions to mitigate or respond to erosion and sedimentation can impact the environment and erosion/sedimentation in adjacent areas.

8.3.2 Strategies to address erosion and sedimentation in terrestrial environments

Erosion protection starts with best practices for erosion avoidance. Earthworks designers for fills including building pads, road embankments, bridge approaches and abutment fills, airstrips, containment berms, reservoir, or lagoon berms shall consider the following strategies to reduce the likelihood of erosion:

a) prevent the installation of sidecast fills, whose sloped configuration and lack of compaction is highly likely to lead to sloughing and release of sediment;
b) reduce the gradient of fill slopes, especially for projects located in communities or regions where coarse-grained fill is in short supply, and on slopes expected to be prone to snow drifting, thus reducing the rate of fill slope oversteepening (or likelihood thereof) resulting from maintenance operations such as snow-plowing, or grading or topping-up of gravel surfacing;
c) choose cross-drain locations (e.g., culverts) to preferentially allow drainage at existing streams or swales. Where obvious cross-drainage sites are not present, other measures such as permeable underdrains and/or other suitably-spaced cross-drain types shall be considered as appropriate to reduce the likelihood of water being blocked at the embankment (TAC 2010);
d) avoid routing concentrated surface water, e.g., from culvert outlets, over ice-rich permafrost terrain where concentrated water does not naturally flow;
e) confirm that culverts and other cross-drain types extend far enough beyond the toes of the road embankment fill, so that fill erosion, or maintenance operations such as snow-plowing, or grading or topping-up of gravel surfacing during the service life, do not render the culverts too short, or even blocked with sloughed or bladed soil material, before the end of their service life. Culvert extensions beyond the road embankment shall have sufficient provisions, including appropriate base preparation and cover, to reduce the likelihood of frost-jacking of the culvert ends or large seasonal variations in culvert temperatures due to conduction from the exposed ends (TAC 2010);
f) confirm that the local terrain and the design will allow the necessary cover over culverts, reducing the likelihood of blocked culverts or damage to the culverts (such as crushing or splitting open) during snow plowing or road grading;
g) plan for markers at culvert ends to reduce likelihood of damage to culverts or incorrect placement of materials during maintenance work that could result in blockage of the culvert, and related erosion or sedimentation;
h) plan for additional fill thickness required over ice-rich permafrost to mitigate against the likelihood of thaw at the embankment toes and resulting embankment settlement or failure;
i) avoid cut in ice-rich permafrost;
j) plan for a wider right-of-way so that ditches, if used, can be placed a minimum of 10 m away from driving surfaces or foundation elements to reduce the likelihood of permafrost thaw and embankment settlement or failure to affect infrastructure elements or safety;
k) be judicious in the choice of borrow areas to avoid materials with high fines content or ice content, especially for fills to be constructed in winter and expected to gradually thaw, beginning as early as the following thaw season;
l) if suboptimal fill materials are unavoidable, or difficult to identify during winter extraction and placement, plan for alternative methods of material preparation so that high-ice-content material is not placed in the embankment;
m) design culvert sizes at two to three times the size used in non-permafrost areas to compensate for design uncertainties; ice, snow and sediment blockage, as well as possible settlement (TAC 2010);
n) design cross-drains with backup, including additional drains such as culverts at staggered locations and higher up on the embankment so that early-season drainage can still occur if the lower cross-drains are still blocked with snow or ice; and
o) if the design strategies for maintaining cross-drainage in winter prove inadequate, an interim solution could be to thaw frozen, blocked culverts using steam circulated through a 19 mm

diameter pipe mounted in the culvert (common in Alaska), or with a resistance wire inside the culvert that can be periodically connected for thawing (an alternative to heat tape that is permanently connected to a power source) (TAC 2010). However, either solution is labour-intensive and energy-intensive, requiring both staff and equipment for successful implementation. Also, depending on the ice content of the underlying soil and the culvert installation details, this method might not be suitable for all locations.

8.4 Structural measures

Many of the structures and strategies described in mitigating erosion and sedimentation in coastal/lakeshore or open-channel environments (Clauses 6 and 7) can also be appropriate for use in terrestrial environments. Consideration of erosion and sedimentation mitigation measures shall include, but is not limited to the following:

a) Dikes or berms – used to limit surface water runoff in areas susceptible to erosion. These can be armoured if required for long-term resistance against erosion, or merely tarped, especially for temporary installations, for example, if they are used to limit runoff from stockpiles. Concentrated surface water should not be routed on, or directed to, locations underlain by ice-rich permafrost.

b) Retaining walls – used to support and tie back slopes or fill soils, either as part of the design of the infrastructure (e.g., a building, bridge or road), or to reduce the likelihood of a slope failure and consequent release of sediment that can then erode and deposit elsewhere. Retaining walls also serve to reduce upslope gradients, thus reducing water velocity and erosion. Retaining walls can be as simple as timber cribs or gabions or bin walls (local conditions and material availability permitting), or as complex as mechanically stabilized earth walls with concrete panels.

c) Buttresses – used to support slopes; can allow steeper cutslopes or fillslopes along roads while protecting the slopes from sloughing and erosion, and sometimes mitigating permafrost thaw. Usually made of large angular rock that also serves as riprap.

d) Revetments – cladding structures to protect slopes from erosion, often consisting of armour stone or rock, gravel bags, geotextiles, and geomattresses. For example, performance of cutslopes in permafrost can be improved with backslope protection consisting of geotextile with 0.5 m cover of granular material (TAC 2010).

e) Soft-engineering techniques – nature-based solutions including bio-engineering, slope stabilization and disturbed-surface stabilization using mulches and matting, and other revegetation techniques.

f) Thermosyphons or thermoprobes – to protect a site from permafrost thaw, including natural or man-made slopes (e.g., a creeping permafrost slope supporting a utilidor, bridge approaches on warm permafrost). This expensive solution may be considered to protect critical infrastructure and has the added benefit of reducing the likelihood of erosion and sedimentation from a slope failure. As discussed in Clause 7.4, additional strategies might also be applicable to mitigate permafrost thaw, including reflectors to reduce or prevent solar radiation reaching the site (Ravens and Ulmgren 2019). Other strategies might also be applicable, as demonstrated by a series of permafrost test sections along the Alaska Highway, Yukon, including air convection embankments, light-coloured aggregate, longitudinal culverts, and snow/sun sheds (Malenfant-Lepage et al. 2012).

Note: *See GNWT DOT 2013 and/or TAC 2010 for more information on the different types of structural measures potentially applicable in terrestrial environments. Information provided in TAC 2010 governs in permafrost environments.*

There is also considerable overlap in the strategies for erosion and sedimentation mitigation in each environment that do not necessarily entail physical structures. Best management practices for the terrestrial-based portions of coastal and lakeshore, open-channel and terrestrial mitigations are provided in Clause 9.

9 Best practices for managing erosion and sedimentation

9.1 General

Erosion and sediment mobilization can be initiated in the thaw season by thermal erosion or other permafrost changes, by unexpected rainfall, flood events, concentrated surface water flows, ice jams and ice break-up, wind, and vehicle tracking, all of which require appropriate mitigations. An ESCP is intended to mitigate erosion and sediment mobilization. A large number of best management practices (BMPs) have been established for this purpose, which can be divided into four broad categories as presented in Clause 9:

a) site management;
b) erosion control;
c) sedimentation control; and
d) air quality control.

These BMPs are considered well-suited for typical projects in the coastal and lakeshore, open-channel, and terrestrial environments of northern Canada, but are not exhaustive, nor necessarily applicable to each project. Therefore, a qualified professional shall develop the ESCP to incorporate the applicable BMPs, and additional requirements as needed. An ESC coordinator shall then oversee the implementation of the BMPs.

Working in frozen and harsh conditions (e.g., winter construction) can make ESC implementation, inspection, and monitoring much more challenging in Canada's North than it is in the South. Therefore, concerted efforts shall be made in understanding and satisfying the requirements of the Clauses 4 through 8 before a project reaches the construction stage, or before attempting to remediate an existing problem, whether it be a natural event affecting community infrastructure or a project-related event.

Note: *Further information about ESC coordinators is provided in Clause 12 and Annex B. Additional information on selected BMPs is provided in Annex C.*

9.2 Erosion and sediment control plans

Based on the findings from the site-specific assessment, and in accordance with the project requirements, a qualified engineer or engineering team shall determine the requirements for an ESCP. In addition to the ESCP, if ice-rich permafrost is present on the project site, or will be affected by activities on the project site, specific geotechnical strategies shall be designed as appropriate to reduce the likelihood of rapid and unexpected permafrost thaw, with a monitoring system established to provide an early warning in the event that remedial measures are required prior to the end of the service life.

The ESCP shall include the following elements:

a) a statement of the primary purpose or objectives of the ESCP (e.g., bank protection, scour protection, protection of off-site receptors, loss of permafrost, etc.);
b) a summary of the risks identified at the project site, including risks due to ice-rich permafrost;
c) identification of potential areas of concern, including protected areas (eco-type or other) and water bodies;
d) if ice-rich permafrost is present, the ESCP shall include provisions for specific inspections and monitoring of at-risk areas, as described above;
e) location, timing, and construction techniques to avoid erosion and minimize impacts of sediment release, such as working in frozen conditions;
f) summary and justification of proposed erosion and sediment control strategies;

g) a summary of the proposed conditions upon completion of construction. This summary shall include drawings and specifications sufficient to describe the finished site, including
   i) site grading plans and landscaping plans, including identification of design slope gradients;
   ii) specifications and drawings for structures to be installed, such as energy mitigation structures, seawalls, groynes, spurs, dikes, diversions, revetments, or buttresses;
   iii) specifications and drawings for water collection features such as ditches, culverts, sedimentation basins, and detention basins;
   iv) possible requirements for rock filter dams;
   v) erosion protection and water dispersal at culvert or basin outlets, and so on; and
   vi) potential areas of concern;
h) prioritize stabilization techniques that use natural materials, or materials that can be made available onsite;
i) a filter layer is designed to prevent migration of fines and should be placed below the proposed stabilization material; and
j) sources and costs of all materials needed for construction.

An ESCP shall also include an inspection, monitoring, and maintenance plan, or be used in conjunction with a separate inspection, monitoring, and maintenance plan (see Clause 10).

9.3 Environmental considerations

Environmental considerations in northern regions can present some unique challenges and should be considered early in the design stage of any erosion and sedimentation mitigation measure. Due to the remoteness of many northern regions, environmental monitoring can prove to be more onerous due to limitations with site access, construction equipment availability, construction techniques, material availability, consequence on the environment, etc. A qualified professional shall supervise the placement of any erosion and sediment control measures and confirm the following:
a) all permits have been obtained, from the applicable territorial, provincial, and federal agencies;
b) the timing of the works complies with the timing windows as specified by DFO (DFO 2007-1329);
c) nesting birds and wildlife are protected during construction;
d) a plant survey has been conducted by a registered botanist or biologist with a specialty in botany and recommendations provided by the botanist are followed;
e) the works are conducted during favorable weather and low-flow conditions;
f) logistics to supply all materials has been coordinated;
g) no deleterious substances are discharged to any watercourse (DFO 2007-1329);
h) if hydraulic machinery is required, hydraulic fluids are environmentally-sensitive, non-toxic to aquatic life, and readily or inherently biodegradable;
i) machinery is operated from the bank if possible, and not in the stream channel;
j) if instream works are required, necessary precautions shall be taken to protect the environment, for instance building access berms or cofferdams and using biodegradable hydraulic fluids;
k) excavated materials are placed above the ordinary high water mark (OHWM) as defined by DFO (DFO 2007-1329), and preferably outside of the riparian zone;
l) a contingency plan is in place to address unforeseen storm events that might result in erosion;
m) minimize instream works required;
n) restrict the work area to as small an area as possible;
o) adopt instream sediment controls (e.g., silt barriers, cofferdams, instream weirs, retention basins, wet ponds);
p) outlet protection is installed at the outlets of all ponds, stormwater systems, pipes, culverts, ditches, and anywhere runoff is conveyed to a natural or man-made drainage feature;

q) material such as rock, or other materials placed on the bank, or within the active channel or floodplain, is inert and free of silt, overburden, debris, or other substances deleterious to aquatic life;
r) filter layer(s) are built according to specifications;
s) diversions are constructed where needed. If pumps, pipes, or any other systems are required, they shall be sized to divert, at a minimum, a 1 in 10-year maximum daily flow for the period of construction, noting that no water shall be rerouted over areas of ice-rich permafrost; and
t) the need to establish ESC measures so that they are functional during freshet, recognizing the challenges of working in frozen and harsh conditions as well as the need for adaptations, including permafrost-related adaptions (TAC 2010).

Notes:
1) *The type of environment (i.e., coastal/lakeshore, open-channel, terrestrial) in which a project is situated will affect the applicability of the requirements of this Clause.*
2) *See Clauses 8 and 9 for requirements and BMPs for land-based portions of open-channel environments and projects.*
3) *CAN/CSA-W202 provides additional requirements for in-stream work.*

9.4 Site management

9.4.1 Site access planning

Projects in the North present unique challenges in terms of site access, for both existing or proposed infrastructure. In addition to the requirements of the land and/or project owners, the project team shall incorporate project site access considerations into the project schedule and methodology. Site access considerations in the North shall include, but are not limited to
a) determining the currently available means of access to the site, for example, all-season and/or winter roads, community airstrips or nearby military or mining airstrips, and/or access via sealift or river barge;
b) verifying that the proposed access methods reflect seasonal availability and varying requirements to transport materials required for a specified task (e.g., inspection and monitoring versus construction);
c) the need for terrain mapping and geohazard assessment if road access to the site or to and within borrow or quarry sites must be designed and built;
d) availability of proposed construction materials (local or imported);
e) availability of meals and accommodation for project staff in the community; and
f) the potential need for a wildlife monitor to accompany project staff on site.

9.4.2 Site access

Once the site boundaries are defined, site access shall be controlled as follows:
a) site access shall be restricted to a limited number of points;
b) access points shall be shown on site drawings and site signage;
c) a qualified professional shall determine whether or not gravelled access pads and wheel washes will be required to minimize tracking site sediments off-site;
d) water management around site access shall be considered, and proper mitigation measures, such as covers, drainage ditches, and slope protection shall be implemented; and
e) special site access provisions shall be included as applicable to the site conditions. For example, for sites with poor trafficability in the thaw season or in wet conditions, heavy mechanical equipment shall be used late in the fall or during winter (or early spring) when the ground is frozen, to