

Karst Resources Checklist and Monitoring Protocol – Version #2

The following is Version #2 of the routine/extensive checklist for karst resources based on the results of a stakeholder workshop held in Nanaimo in July 2004. The next step in the development process will be to field test the checklist and associated monitoring protocols. This work is scheduled to occur during the fall/winter of 2004/05.

The routine/extensive checklist for karst resources relies heavily on inventory data collected during a karst field assessment (KFA). KFAs are karst inventories conducted at the cutblock level (1:5000 or 1:10 000 map scale). Ideally, KFAs are conducted prior to operational planning and the initiation of forest development activities.

KFAs delineate karst areas within the cutblock and along proposed access roads into polygons of similar karst vulnerability, and determine the location and significance of specific karst features. Information on the karst unit boundaries within the cutblock, the location of identified karst features, and the vulnerability of the karst is readily available from KFA maps. This type of information is necessary for the effective use of the routine/extensive checklist.

The collection of forest cover baseline data, along with accurate information on the pre-harvest status of karst resources within the proposed cutblock area, would significantly enhance the evaluation information collected by the checklist. It is recommended that KFA procedures be expanded to allow for the collection of relevant pre-harvest baseline data. This baseline data would allow the karst checklist to clearly identify any changes to the status or condition of karst resources resulting from forest management activities.

In addition to reviewing any KFA information prior to evaluating a site, it is recommended that any compliance reports also be consulted.

The Checklist

Part A – Caves

Section 1 - Significant Cave Entrances

Evaluation Question: Have natural microclimatic conditions at the significant cave entrance been maintained?

1.1 Is there a reserve around the cave entrance? ☐ Yes ☐ No

If there is a reserve around the cave entrance:

1.1.1 Is the reserve a minimum of two tree lengths? ☐ Yes ☐ No

Description of reserve if less than two tree lengths (e.g., size in tree lengths, shape, characteristics): _____

Answer the following questions regardless of the size of the reserve:

1.1.2 Is there a management zone to protect the reserve from windthrow?

☐ Yes ☐ No

If Yes, describe the management zone (e.g., size in tree lengths, shape, vegetation): _____

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

1.1.3 Estimate the % of windthrow in the reserve:

Within 10 metres of the cave entrance: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10 metres to one tree length: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

One to two tree lengths: ☐ <5% ☐ 5-15% ☐ 15-30% ☒ >30%

Use this space to record estimated windthrow within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

1.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

1.1.5 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Within 10 metres of the cave entrance: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10 metres to one tree length: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

One to two tree lengths: ☐ <5% ☐ 5-15% ☐ 15-30% ☒ >30%

Use this space to record estimated felled trees within site-specific alternative distances if the size of the reserve does not fit into any of the above categories:

If there is NOT a reserve around the cave entrance:

1.2 Is the cave entrance being managed with a management zone?

☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

1.2.1 Estimate the % of windthrow in the management zone:

Within 10 metres of the cave entrance: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10 metres to the end of the management zone: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

1.3 Were any strategies other than a reserve or a management zone utilized to manage for microclimate around the cave entrance? ☐ Yes ☐ No

If Yes, describe: _____

1.4 Is there any evidence of soil disturbance attributed to forest practices on any sideslopes leading to the cave entrance? ☐ Yes ☐ No

If Yes, estimate the amount of disturbance based on the surface area of the sideslopes leading to the cave entrance: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

Cause of disturbance: ☐ first pass harvesting ☐ recent harvesting ☐ natural causes

☐ unknown

1.5 Has air flow at the cave entrance been impeded by windthrow or logging debris? ☐ Yes ☐ No

If Yes, estimate the percent of blockage based on the cross-sectional area of the cave entrance: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

1.6 Has water flow at the cave entrance been impeded by windthrow or logging debris? ☐ Yes ☐ No

If Yes, estimate the percent of blockage based on the cross-sectional area of the cave entrance:

☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

1.7 Is there an observable change in the plant community within and around the cave entrance (e.g., desiccated mosses, invasive species, etc.)?

☐ Yes ☐ No ☐ unknown

If Yes, describe: _____

1.8 Based on the above observations, how effective have forest practices been in maintaining natural microclimatic conditions at the cave entrance? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum two-tree-length retention area around significant cave entrances to maintain natural microclimate and habitat conditions. This recommendation is based on research suggesting that 2-4 tree lengths are required for maintaining “interior forest conditions.”

It is important to maintain the microclimate of significant cave entrances to ensure air flow, water flow, air temperature, relative humidity, and level of shading remain constant so as not to alter conditions for air and water exchange, surface and subsurface habitats, ongoing cave processes, etc. Maintaining the biological integrity of the cave entrance is also important for maintaining stable habitat conditions for localized flora and fauna, as well as cave-dwelling organisms that forage for food in the cave entrance or rely on organic matter from the entrance falling into the cave as a food source.

The amount of windthrow and/or tree removal around a cave entrance directly affects the level of canopy closure, the level of shading, and the amount of solar radiation reaching the forest floor. It may also affect the amount of wind that might reach the cave entrance through openings created in the stand. As the level of canopy closure and shading diminishes, and the amount of solar radiation increases, air temperatures at the cave entrance may rise, while relative humidity may decrease, thereby altering microclimatic and habitat conditions at the cave entrance.

Maintaining as close to natural pre-harvest stand conditions as possible nearest the cave entrance is a priority for maintaining natural microclimatic and habitat conditions, as well as for preventing logging debris from obstructing or entering the cave system. As the distance increases away from the entrance, proportionately more windthrow and/or tree removal may be tolerated within acceptable limits.

Field Methodologies:

- Estimating average tree heights for the site can be obtained from forest cover maps if the area is located in old growth. If the cutblock is located in second growth, the

reference tree height should be established using site potential rather than actual tree heights as the second-growth stand may not yet have reached its full height potential.

- To estimate the amount of windthrow/felled trees in the reserve within the recommended distances from the cave entrance, mark off the 10 m, one tree length, and two tree-length distances with flagging. Visually estimate the amount of windthrow/felled trees in each distance category by traversing through the area. In some cases, it may be easier to divide the reserve into quarters based on cardinal points. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used around the cave entrance instead of the recommended reserve), mark off the 10 m distance with flagging and visually estimate the amount of windthrow/felled trees within that area. Traverse through the remaining area of the management zone to visually estimate the amount of windthrow/felled trees in that area. In some cases, it may be easier to divide the management zone into quarters based on cardinal points.
- To estimate the amount of soil disturbance on any sideslopes leading to the cave entrance, it may be helpful to divide the surface area of the sideslopes into quarters based on cardinal points to come up with more accurate percentages.
- Logging debris can be easily identified by looking for saw cuts.

Section 2 - Cave Entrances Not Classified as Significant

Evaluation Question: Has the integrity of the cave entrance been maintained?

2.1 Is there a management zone around the cave entrance? ☐ Yes ☐ No

If Yes:

2.1.1 Is the management zone a minimum of 20 metres? ☐ Yes ☐ No

Description of management zone if less than 20 metres (e.g., size, shape, characteristics):

Identify the retention within the management zone:

☐ Windfirm non-merchantable trees

☐ Advanced regeneration

☐ Wildlife trees

☐ Other windfirm vegetation (describe): _____

2.2 Is there any evidence of soil disturbance attributed to windthrow on any sideslopes leading to the cave entrance? ☐ Yes ☐ No

If Yes, estimate the amount of disturbance based on the surface area of the sideslopes leading to the cave entrance: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

2.3 Is there any evidence of soil disturbance attributed to forest practices on any sideslopes leading to the cave entrance? ☐ Yes ☐ No

If Yes, estimate the amount of disturbance based on the surface area of the sideslopes leading to the cave entrance: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Cause of disturbance: ☐ first pass harvesting ☐ recent harvesting ☐ natural causes
☐ unknown

2.4 Is the cave entrance free of logging slash and/or road construction material?
☐ Yes ☐ No

If No, estimate the percent of blockage based on the cross-sectional area of the cave entrance: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

2.5 Based on the above observations, how effective have forest practices been in maintaining the integrity of the cave entrance? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Caves not classified as significant are not as susceptible to forest practices as significant caves. Nevertheless, soil disturbance around the entrance should be kept to a minimum to prevent soil transfer to the subsurface. Retaining windfirm non-merchantable trees, wildlife trees, advanced regeneration, and/or other windfirm vegetation will help stabilize

soils around the cave entrance. Any logging debris that enters the cave should be removed so as not to interfere with air and/or water exchange.

Field Methodologies:

- To estimate the amount of soil disturbance on any sideslopes leading to the cave entrance, it may be helpful to divide the surface area of the sideslopes into quarters based on cardinal points to come up with more accurate percentages.
- Logging debris can be easily identified by looking for saw cuts. Road construction material can be identified by the presence of blasted rock (straight or broken edges).

Section 3 - Significant Caves <3X the Greatest Dimension of the Cave or <10 m Below the Surface

Evaluation Question: Have stable conditions for karst processes above the significant cave been maintained?

3.1 Is there a reserve above the cave? ☐ Yes ☐ No

If there is a reserve above the cave:

3.1.1 Does the size and shape of the reserve cover the diffuse percolation area above the cave based on a 45-degree angle projected to the surface from the cave walls?

☐ Yes ☐ No

Description of the reserve if it does not cover the diffuse percolation area based on the 45-degree principle (e.g., shape and size):

3.1.2 Is there a management zone to protect the reserve from windthrow?

☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

3.1.3 Estimate the % of windthrow in the reserve:

☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

3.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

3.1.5 Did any windthrow occur on exposed, well-developed epikarst surfaces?

☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

3.1.6 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

If there is NOT a reserve above the cave:

3.2 Is the diffuse percolation area above the cave being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

3.2.1 Estimate the % of windthrow in the management zone:

☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

3.3 Were any strategies other than a reserve or management zone utilized to maintain stable conditions for karst processes above the cave? ☐ Yes ☐ No

If Yes, describe: _____

3.4 Based on the above observations, how effective have forest practices been in maintaining stable conditions for karst processes above the cave? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Significant caves situated less than 3x the greatest dimension (height or width) of the cave and less than 10 m below the surface are susceptible to disturbances in the infiltration area overlying the cave. The infiltration area is determined by projecting a 45-degree angle upwards from the cave walls to the surface (represents the most intense zone of potential water infiltration for the cave)¹. Disturbances within this area can affect important factors related to karst processes, such as soil temperature and humidity, infiltration rates, and drip water chemistry. Retaining an intact forest cover above a significant cave will maintain stable conditions in the infiltration area and protect the resources of the underlying cave.

Disturbance to the forest canopy within the infiltration area due to windthrow or tree removal can decrease the level of shade cover, thereby increasing soil temperatures and decreasing soil humidity. This can reduce infiltration rates and affect the chemistry of drip water.

Windthrow occurring on exposed, well-developed epikarst within the infiltration area can result in soil loss into epikarst cavities. This soil can be transmitted downward to clog

¹ Derek Ford, personal communication.

fissures and other subsurface openings, blocking infiltration access points and possibly discolouring drip water and cave formations.

Field Methodologies:

- To determine if the size and shape of the reserve covers the diffuse percolation area above the cave based on the 45-degree principle, consult the cave maps and surface projections used by the licensee.
- Visually estimate the amount of windthrow/felled trees in the reserve above the cave by traversing through the area. Smaller reserves can probably be traversed using a single traverse line with minor deviations. Larger reserves may require multiple transects to effectively cover the area. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- If a management zone is used above the cave instead of the recommended reserve, use a similar methodology to traverse the area to estimate the amount of windthrow/felled trees.

Section 4 - Significant Caves >3X the Greatest Dimension of the Cave or >10 m Below the Surface that are Known to Contain Exceptional Features or Values

Evaluation Question: Was soil humidity maintained and soil disturbance minimized above the significant cave?

4.1 Is there a management zone above the cave? ☐ Yes ☐ No

If there is a management zone above the cave:

4.1.1 Does the size and shape of the management zone cover the diffuse percolation area above the cave based on a 45-degree angle projected to the surface from the cave walls? ☐ Yes ☐ No

Description of the management zone if it does not cover the diffuse percolation area based on the 45-degree principle (e.g., shape and size):

4.1.2 Estimate the % of windthrow in the management zone:

☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

If the soil layer in the management zone above the cave is less than 0.5 m deep:

4.2 Were additional amounts of CWD and non-merchantable vegetation retained to help maintain soil humidity? ☐ Yes ☐ No ☐ unknown

4.3 Was the level of soil disturbance minimized? ☐ Yes ☐ No

Estimated level of soil disturbance in the management zone:

☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

If the soil layer in the management zone above the cave is more than 0.5 m deep:

4.4 Were additional amounts of CWD and non-merchantable vegetation retained to help maintain soil humidity? ☐ Yes ☐ No ☐ unknown

4.5 Based on the above observations, how effective have forest practices been in maintaining stable conditions for karst processes above the cave? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Significant caves situated more than 3x the greatest dimension (height or width) of the cave and more than 10 m below the surface are less susceptible to disturbances in the infiltration area overlying the cave. However, significant caves with exceptional cave resources (e.g., highly unique/rare/unusual) may need special consideration to ensure cave contents are protected. If the soil layer in the infiltration area is greater than 0.5 m deep, the retention of additional CWD and non-merchantable vegetation will help maintain soil humidity. The amount of CWD and non-merchantable vegetation within

the infiltration area above the cave will give a reasonable indication as to soil humidity levels. If the soil layer in the infiltration area is less than 0.5 m deep, soil disturbance will need to be minimized (e.g., partial cutting, maximum/full suspension yarding), in addition to retaining more CWD and non-merchantable vegetation to maintain soil humidity.

Field Methodologies:

- To estimate the depth of soil within the management zone above the cave, traverse the area taking representative soil depth samples using a calibrated, metre-long steel probe similar to the type used for karst field assessments (i.e., a 5 mm diameter steel rod with decimetre interval markings). Soil depth estimates are extrapolated to the area not sampled by the probe. Soil thickness can be highly variable on karst terrain, with thinner soils on ridges or hums and thicker soils in the intervening low areas. Obtain an average soil thickness for variable terrain. When estimating soil depth, include the forest litter or duff layer (in many cases, forest litter or duff may be the only material overlying epikarst).

Part B – Surface Karst Features

Section 5 - Significant Sinkholes with Microclimates

Evaluation Question: Have natural microclimatic conditions within the sinkhole been maintained?

5.1 Is there a reserve around the sinkhole? ☐ Yes ☐ No

If there is a reserve around the sinkhole:

5.1.1 Is the reserve a minimum of two tree lengths? ☐ Yes ☐ No

Description of reserve if less than two tree lengths (e.g., size in tree lengths, shape, characteristics): _____

Answer the following questions regardless of the size of the reserve:

5.1.2 Is there a management zone to protect the reserve from windthrow?

☐ Yes ☐ No

If Yes, describe the management zone (e.g., size in tree lengths, shape, vegetation): _____

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

5.1.3 Estimate the % of windthrow in the reserve:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m from the rim to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

One to two tree lengths: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated windthrow within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

5.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

5.1.5 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m from the rim to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

One to two tree lengths: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated felled trees within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

If there is NOT a reserve around the sinkhole:

5.2 Is the sinkhole being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

5.2.1 Estimate the % of windthrow in the management zone:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10m from rim to end of the management zone: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

5.3 Were any strategies other than a reserve or a management zone utilized to manage for microclimate around the sinkhole? ☐ Yes ☐ No

If Yes, describe: _____

5.4 Are the sinkhole sideslopes and bottom intact? ☐ Yes ☐ No

If No, estimate the amount of soil disturbance based on the surface area of the sinkhole:

(sideslopes and bottom) ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

Cause of disturbance: ☐ first pass harvesting ☐ recent harvesting ☐ natural causes

☐ unknown

5.5 Is the inside of the sinkhole free of logging debris? ☐ Yes ☐ No

If No, estimate the amount of debris based on the surface area of the sinkhole (sideslopes and bottom): ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

5.6 Is there an observable change in the plant community within the sinkhole (e.g., desiccated mosses, invasive species, etc.)? ☐ Yes ☐ No ☐ unknown

If Yes, describe: _____

5.7 Based on the above observations, how effective have forest practices been in maintaining natural microclimatic conditions within the sinkhole? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum two-tree-length retention area to maintain natural microclimate and habitat conditions within sinkholes large enough to create their own microclimates. This recommendation is based on research suggesting that 2-4 tree lengths are required for maintaining “interior forest conditions.”

The amount of windthrow and/or tree removal within the sinkhole and in the area around the sinkhole directly affects the level of canopy closure, the level of shading, and the amount of solar radiation reaching the forest floor. It may also affect the amount of wind that might reach the sinkhole through openings created in the stand. As the level of canopy closure and shading diminishes, and the amount of solar radiation increases, air temperatures within the sinkhole may rise, while relative humidity may decrease, thereby altering microclimatic and habitat conditions. Maintaining the biological integrity of the sinkhole is also important for maintaining stable habitat conditions for localized flora and fauna.

Maintaining as close to natural pre-harvest stand conditions as possible within and in the immediate area around the sinkhole is a priority for maintaining natural microclimatic and habitat conditions, avoiding disturbance to the sideslopes and rim, and preventing logging debris from entering the sinkhole. As the distance increases away from the sinkhole, proportionately more windthrow and/or tree removal may be tolerated within acceptable limits.

Field Methodologies:

- Estimating average tree heights for the site can be obtained from forest cover maps if the area is located in old growth. If the cutblock is located in second growth, the reference tree height should be established using site potential rather than actual tree heights as the second-growth stand may not yet have reached its full height potential.
- To estimate the amount of windthrow/felled trees in the reserve within the recommended distances from the sinkhole, mark off the 10 m, one tree length, and two tree-length distances with flagging. Visually estimate the amount of windthrow/felled trees in each distance category by traversing through the area. In some cases, it may be easier to divide the reserve into quarters based on cardinal points. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used around the sinkhole instead of the recommended reserve), mark off the 10 m distance with flagging and visually estimate the amount of windthrow/felled trees within that area. Traverse through the remaining area of the management zone to visually estimate the amount of windthrow/felled trees in that area. In some cases, it may be easier to divide the management zone into quarters based on cardinal points.
- To estimate the amount of soil disturbance over the surface area of a sinkhole (sideslopes and bottom), it may be helpful to divide the sinkhole into quarters based on cardinal points to come up with more accurate percentages. This procedure may also be useful for estimating the amount of logging debris covering the surface area of the sinkhole. Logging debris can be easily identified by looking for saw cuts.

Section 6 - Significant Sinkholes Without Microclimates

Evaluation Question: Has the significant sinkhole been protected from physical damage?

6.1 Is there a reserve around the sinkhole? ☐ Yes ☐ No

If there is a reserve around the sinkhole:

6.1.1 Is the reserve a minimum of one tree length? ☐ Yes ☐ No

Description of reserve if less than one tree length (e.g., size in tree lengths, shape, characteristics): _____

Answer the following questions regardless of the size of the reserve:

6.1.2 Is there a management zone to protect the reserve from windthrow?

☐ Yes ☐ No

If Yes, describe the management zone (e.g., size in tree lengths, shape, vegetation): _____

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

6.1.3 Estimate the % of windthrow in the reserve:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m from the rim to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated windthrow within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

6.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

6.1.5 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m from the rim to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated felled trees within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

If there is NOT a reserve around the sinkhole:

6.2 Is the sinkhole being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation): _____

Identify any treatments in the management zone:

- ☐ Feathering
- ☐ Topping
- ☐ Other: _____
- ☐ No Treatment

6.2.1 Estimate the % of windthrow in the reserve:

Within the sinkhole and up to 10m from the rim: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%
10m from rim to end of management zone: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

6.3 Were any strategies other than a reserve or a management zone utilized to protect the sinkhole from physical damage? ☐ Yes ☐ No

If Yes, describe: _____

6.4 Are the sinkhole sideslopes intact? ☐ Yes ☐ No

If No, estimate the amount of soil disturbance based on the surface area of the sinkhole (sideslopes and bottom): ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Cause of disturbance: ☐ first pass harvesting ☐ recent harvesting ☐ natural causes
☐ unknown

6.5 Is the inside of the sinkhole free of logging debris? ☐ Yes ☐ No

If No, estimate the amount of debris based on the surface area of the sinkhole (sideslopes and bottom): ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

6.6 Based on the above observations, how effective have forest practices been in protecting the sinkhole from physical damage? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum one-tree-length retention area around significant surface karst features, including significant sinkholes that do not generate their own microclimates. One-tree-length is considered adequate to protect significant sinkholes from disturbance or physical damage during forest operations.

Maintaining as close to natural pre-harvest stand conditions as possible within and in the immediate area around the sinkhole is a priority for avoiding disturbance to the sideslopes and rim, and preventing logging debris from entering the sinkhole. As the distance increases away from the sinkhole, proportionately more windthrow and/or tree removal may be tolerated within acceptable limits.

Field Methodologies:

- Estimating average tree heights for the site can be obtained from forest cover maps if the area is located in old growth. If the cutblock is located in second growth, the reference tree height should be established using site potential rather than actual tree heights as the second-growth stand may not yet have reached its full height potential.
- To estimate the amount of windthrow/felled trees in the reserve within the recommended distances from the sinkhole, mark off the 10 m and one tree length distances with flagging. Visually estimate the amount of windthrow/felled trees in each distance category by traversing through the area. In some cases, it may be easier to divide the reserve into quarters based on cardinal points. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used around the sinkhole instead of the recommended reserve), mark off the 10 m distance with flagging and visually estimate the amount of windthrow/felled trees within that area. Traverse through the remaining area of the management zone to visually estimate the amount of windthrow/felled trees in that area. In some cases, it may be easier to divide the management zone into quarters based on cardinal points.
- To estimate the amount of soil disturbance over the surface area of a sinkhole (sideslopes and bottom), it may be helpful to divide the sinkhole into quarters based on cardinal points to come up with more accurate percentages. This procedure may also be useful for estimating the amount of logging debris covering the surface area of the sinkhole. Logging debris can be easily identified by looking for saw cuts.

Section 7 - Sinkholes Not Classified as Significant

Evaluation Question: Has the integrity of the sinkhole been maintained?

7.1 Was windfirm non-merchantable vegetation retained within and around the sinkhole? ☐ Yes ☐ No

If Yes, identify the type of retention:

- ☐ Non-merchantable trees
- ☐ Advanced regeneration
- ☐ Wildlife trees
- ☐ Other vegetation (describe): _____

7.2 Is there any evidence of soil disturbance attributed to windthrow on the rim, sideslopes or bottom of the sinkhole? ☐ Yes ☐ No

If Yes, estimate the amount of disturbance based on the surface area of the sinkhole (rim, sideslopes and bottom): ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

7.3 Is there any evidence of soil disturbance attributed to forest practices on the rim, sideslopes or bottom of the sinkhole? ☐ Yes ☐ No

If Yes, estimate the amount of disturbance based on the surface area of the sinkhole (rim, sideslopes and bottom): ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Cause of disturbance: ☐ first pass harvesting ☐ recent harvesting ☐ natural causes
☐ unknown

7.4 Is the sinkhole free of logging slash and/or road construction material?

☐ Yes ☐ No

If No, estimate the amount based on the surface area of the sinkhole (sideslopes and bottom): ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

7.5 Based on the above observations, how effective have forest practices been in maintaining the integrity of the sinkhole? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Sinkholes not classified as significant should be managed in a manner that minimizes soil disturbance to the sideslopes and rim to prevent the transfer of soil/sediment to the subsurface. Retaining windfirm non-merchantable trees, wildlife trees, advanced regeneration, and/or other windfirm vegetation within and around the sinkhole will help stabilize soils. Any logging debris that enters the sinkhole should be removed so as not to interfere with subsurface connections.

Field Methodologies:

- To estimate the amount of soil disturbance over the surface area of a sinkhole (sideslopes and bottom), it may be helpful to divide the sinkhole into quarters based on cardinal points to come up with more accurate percentages. This procedure may also be useful for estimating the amount of logging debris covering the surface area of the sinkhole.
- Logging debris can be easily identified by looking for saw cuts. Road construction material can be identified by the presence of blasted rock (straight or broken edges).

Section 8 – Other Significant Surface Karst Features

Type of feature: _____

Evaluation Question: Has the significant surface karst feature been protected from physical damage?

8.1 Is there a reserve around the surface karst feature? ☐ Yes ☐ No

If there is a reserve around the surface karst feature:

8.1.1 Is the reserve a minimum of one tree length? ☐ Yes ☐ No

Description of reserve if less than one tree length (e.g., size in tree lengths, shape, characteristics): _____

Answer the following questions regardless of the size of the reserve:

8.1.2 Is there a management zone to protect the reserve from windthrow? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size in tree lengths, shape, vegetation): _____

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

8.1.3 Estimate the % of windthrow in the reserve:

Within 10 metres of the feature: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10 metres to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated windthrow within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

8.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

8.1.5 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Within 10 metres of the feature: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10 metres to one tree length: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated felled trees within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

If there is NOT a reserve around the surface karst feature:

8.2 Is the feature being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

8.2.1 Estimate the % of windthrow in the management zone:

Within 10 metres of the feature: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10 metres to end of management zone: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

8.3 Were any strategies other than a reserve or a management zone utilized to protect the feature from physical damage? ☐ Yes ☐ No

If Yes, describe: _____

8.4 Is the feature free of logging debris? ☐ Yes ☐ No

If No, estimate the amount of debris based on the surface area of the feature:

☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

8.5 Based on the above observations, how effective have forest practices been in protecting the surface karst feature from physical damage? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum one-tree-length retention area around significant surface karst features. Significant surface karst features can include features that are directly connected to the subsurface (e.g., grikes or shafts) or other features such as karst canyons or rock arches. One-tree-length is considered adequate to protect significant surface karst features from disturbance or physical damage during forest operations.

Maintaining as close to natural pre-harvest stand conditions as possible in the immediate area around the feature is a priority for avoiding physically damaging the feature and preventing logging debris from entering the feature. As the distance increases away from the sinkhole, proportionately more windthrow and/or tree removal may be tolerated within acceptable limits.

Field Methodologies:

- Estimating average tree heights for the site can be obtained from forest cover maps if the area is located in old growth. If the cutblock is located in second growth, the

reference tree height should be established using site potential rather than actual tree heights as the second-growth stand may not yet have reached its full height potential.

- To estimate the amount of windthrow/felled trees in the reserve within the recommended distances from the sinkhole, mark off the 10 m and one tree length distances with flagging. Visually estimate the amount of windthrow/felled trees in each distance category by traversing through the area. In some cases, it may be easier to divide the reserve into quarters based on cardinal points. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used around the feature instead of the recommended reserve), mark off the 10 m distance with flagging and visually estimate the amount of windthrow/felled trees within that area. Traverse through the remaining area of the management zone to visually estimate the amount of windthrow/felled trees in that area. In some cases, it may be easier to divide the management zone into quarters based on cardinal points.
- Logging debris can be easily identified by looking for saw cuts.

Section 9 – Other Surface Karst Features Not Classified as Significant

Type of feature: _____

Evaluation Question: Has the integrity of the surface karst feature been maintained?

9.1 Is there any evidence of physical damage to the feature? ☐ Yes ☐ No

If Yes, describe the damage _____

9.2 Is the feature free of logging slash and/or road construction material?

☐ Yes ☐ No

If No, estimate the amount based on the surface area of the feature:

☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

9.3 Based on the above observations, how effective have forest practices been in maintaining the integrity of the feature? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Other surface karst features not classified as significant should be managed in a manner that does not physically damage the feature, minimizes soil disturbance within or around the feature, and keeps the feature free of logging debris. Retaining windfirm non-merchantable trees, wildlife trees, advanced regeneration, and other windfirm vegetation within and around the feature will help stabilize soils. Any logging debris that enters the feature should be removed.

Field Methodologies:

- Logging debris can be easily identified by looking for saw cuts. Road construction material can be identified by the presence of blasted rock (straight or broken edges).

Section 10 - Significant Karst Springs

Evaluation Question: Has the significant karst spring been protected from physical damage?

10.1 Is there a reserve around the spring? ☐ Yes ☐ No

If there is a reserve around the spring:

10.1.1 Is the reserve a minimum of 20 metres? ☐ Yes ☐ No

Description of reserve if less than 20 metres (e.g., size, shape, characteristics):

Answer the following questions regardless of the size of the reserve:

10.1.2 Is there a management zone to protect the reserve from windthrow? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

10.1.3 Estimate the % of windthrow in the reserve:

Up to 10m from the spring: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated windthrow within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

10.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed

% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10.1.5 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Up to 10m from the spring: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

10m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

Use this space to record estimated felled trees within site-specific alternative distances if the size of the reserve does not fit into any of the above categories

If there is NOT a reserve around the spring:

10.2 Is the spring being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

- ☐ Feathering
- ☐ Topping
- ☐ Other: _____
- ☐ No Treatment

10.2.1 Estimate the % of windthrow in the management zone:

Up to 10m from the spring: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10m to the end of the management zone: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

10.3 Were any strategies other than a reserve or a management zone utilized to protect the spring from physical damage? ☐ Yes ☐ No

If Yes, describe: _____

10.4 Is there any windthrow or logging debris obstructing the discharge point of the spring? ☐ Yes ☐ No

If Yes, estimate the amount based on the surface area of the spring:

☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

10.5 Based on the above observations, how effective have forest practices been in protecting the spring from physical damage? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a 20-m retention area around significant karst springs to protect the discharge point from physical damage or obstruction by logging debris.

Field Methodologies:

- Estimating average tree heights for the site can be obtained from forest cover maps if the area is located in old growth. If the cutblock is located in second growth, the reference tree height should be established using site potential rather than actual tree heights as the second-growth stand may not yet have reached its full height potential.
- To estimate the amount of windthrow/felled trees in the reserve within the recommended distances from the sinkhole, mark off the 10 m and 20 m distances with flagging. Visually estimate the amount of windthrow/felled trees in each distance category by traversing through the area. In some cases, it may be easier to divide the reserve into quarters based on cardinal points. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.

- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used around the spring instead of the recommended reserve), mark off the 10 m distance with flagging and visually estimate the amount of windthrow/felled trees within that area. Traverse through the remaining area of the management zone to visually estimate the amount of windthrow/felled trees in that area. In some cases, it may be easier to divide the management zone into quarters based on cardinal points.
- Logging debris can be easily identified by looking for saw cuts.

Section 11 - Karst Springs Not Classified as Significant

Evaluation Question: Has the integrity of the karst spring been maintained?

11.1 Is the discharge point of the spring free of logging debris and/or road construction material? ☐ Yes ☐ No

If No, estimate the percent of blockage: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

11.2 Based on the above observation, how effective have forest practices been in maintaining the integrity of the spring? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Springs not classified as significant should be managed in a manner that keeps the discharge point free of any debris that might restrict the flow of water from the spring. Blockage of spring discharge points can result in back flooding of subsurface conduits, which could eventually back up all the way to the sink point and impact flows on the surface (e.g., back flooding along sinking streams, which could impact stream crossings). A reduction in spring discharge would also impact downstream flows, which could have implications for downstream fisheries.

Field Methodologies:

- Logging debris can be easily identified by looking for saw cuts. Road construction material can be identified by the presence of blasted rock (straight or broken edges).

Section 12 - Clusters of Minor Surface Karst Features

Type of Features:_____

Evaluation Question: Were impacts minimized to clusters of minor surface karst features?

12.1 Were trees felled and yarded away from the features?

☐ Yes ☐ No ☐ unable to tell

12.2 Was non-merchantable vegetation retained around the features? ☐ Yes ☐ No

12.3 Is there any logging debris or road construction material in the features?

☐ Yes ☐ No

If Yes, estimate the amount based on the total surface area of the feature cluster: ☐ <5%

☐ 5-15% ☒ 15-30% ☐ >30%

12.4 Is there any evidence of skid trails being constructed through a cluster of minor karst features? ☐ Yes ☐ No

12.5 Was the cluster of minor features treated as a large single feature or unit?

☐ Yes ☐ No

12.6 Based on the above observations, how effective have forest practices been in minimizing impacts to clusters of minor surface karst features? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Individual features within clusters of minor surface karst features are generally not significant in their own right; however, collectively they can represent a localized area of higher subsurface karst development. Due to their dense and sometimes overlapping spacing, these feature clusters can represent operational challenges. Impacts on minor feature clusters can be minimized by falling and yarding away from the features, retaining non-merchantable vegetation around the features, removing logging debris from the features, avoiding skid trails through the cluster, etc. In some cases, it may be more practical to treat the entire cluster as a single large feature or unit to minimize disturbances.

Field Methodologies:

- Logging debris can be easily identified by looking for saw cuts. Road construction material can be identified by the presence of blasted rock (straight or broken edges).

Part C – Sinking/Losing Streams Contributing Water to Significant Recipient Karst Features

Section 13 - If the stream is <1.0m wide on karst or <1.5m wide on non-karst:

Evaluation Question: Has the water quality of the sinking/losing stream been maintained?

Width of stream (metres): _____

13.1 Is the significant recipient karst feature located within 250 metres downstream of the cutblock boundary? ☐ Yes ☐ No

If Yes:

13.1.1 Is there a riparian management zone along the stream for its entire length within the cutblock? ☐ Yes ☐ No

If Yes:

13.1.2 Size of riparian management zone: _____

13.2 Were windfirm non-merchantable trees, wildlife trees, and other vegetation (e.g., understory shrubs, herbs) retained within 5 m of the channel? ☐ Yes ☐ No

13.3 Have any trees with roots embedded in the bank been subjected to windthrow?
☐ Yes ☐ No

13.4 Is there any logging slash or debris in the channel? ☐ Yes ☐ No

13.5 Is there evidence of stream bank disturbance due to crossings, roads, trails, falling, yarding or other forest practices along the length of the stream within the cutblock? ☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Type of disturbance: _____

13.6 Are there any sediment channels entering the stream from stream-side soil disturbance? ☐ Yes ☐ No

If the level of stream bank disturbance within the cutblock suggests that the significant downstream recipient karst feature may have been impacted (i.e., >15% disturbance), evaluation of the recipient karst feature may be required. If the recipient karst feature is evaluated, answer the following questions.

13.7 Are there any fine sediment deposits blanketing substrates in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

13.8 Is there an accumulation of needles, twigs or bark fragments in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

13.9 Is there a build-up of large and/or small woody debris in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

13.10 Based on the above observations, how effective have forest practices been in maintaining the water quality of the sinking/losing stream? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends an appropriately sized riparian management zone for sinking/losing streams <1.0 m wide on karst or <1.5m wide on non-karst that contribute water to a significant recipient karst feature located within 250m downstream of the cutblock boundary. The handbook recommends the following practices within the riparian management zone to maintain the water quality of the sinking/losing stream:

- Retain windfirm trees with roots embedded in the bank;
- Fall and yard away to the fullest extent possible;
- Avoid cross-channel yarding;
- Remove slash and debris that inadvertently enters the channel;
- Retain windfirm non-merchantable trees and other windfirm vegetation (e.g., understory, shrubs, herbs) within five metres of the channel; and
- Retain windfirm wildlife trees.

Woody debris (large and small), sediment, and organic material can be transported downstream where it accumulates and clogs recipient karst features such as swallets or cave entrances. This can restrict water from entering the subsurface and/or redirect flows to other subsurface openings or to the surface. Of particular concern is the introduction of fine sediment (e.g., silts, sands, clays) and fine organic material (e.g., needles, twigs, leaves) into subsurface cavities, including caves. Suspended or dissolved organic materials can coat underground surfaces, impacting subsurface habitats and other cave resources or values (e.g., mineral formations). These materials can coat underground surfaces, thereby impacting subsurface habitats and other cave resources or values (e.g., mineral formations). The slow decay rate associated with underground environments in British Columbia allows the organic component of this material to accumulate and persist over long periods of time. In addition, the decomposition of organic material can lower dissolved oxygen levels in karst waters.

Field Methodologies:

- Refer to the KFA to establish if there are any significant recipient karst features within the allocated distances downstream of the cutblock boundary.
- To estimate the average width of the sinking stream, measure bank-full cross sections at five locations spaced evenly along the reach within the cutblock boundary (i.e., at either edge of the cutblock and three additional locations distributed evenly, if the

stream flows through the entire cutblock). Calculate the average width from the five measurements.

- To determine the amount of stream bank disturbance, walk the stream along its entire length within the cutblock boundary observing both banks for signs of bank erosion. Estimate the percentage of stream bank disturbance by totalling the length of disturbed sites versus the length of the stream within the cutblock boundaries.
- To establish the presence of sediment channels entering the stream, walk the stream along its entire length within the cutblock boundary observing both banks for signs of sediment channels flow into the stream.
- If stream bank disturbance within the cutblock is >15%, use KFA maps to determine the location of the downstream recipient karst feature in order to evaluate any potential impacts at the feature.
- The presence of fine sediment deposits; accumulations of needles, twigs or bark fragments; or a build-up of large and/or small woody debris at the recipient karst feature or just inside the feature indicates the transfer or potential transfer of sediments and organic matter into the subsurface karst environment.

Section 14 - If the stream is 1.0-3.0m wide on karst or 1.5-3.0m wide on non-karst:

Evaluation Question: Has the water quality of the sinking/losing stream been maintained?

Width of stream (metres): _____

Scenario#1:

14.1 Is the significant recipient karst feature located within 500 metres downstream of the cutblock boundary? ☐ Yes ☐ No [Note: If the recipient karst feature is located more than 500 metres downstream of the cutblock boundary, proceed to scenario #2.]

14.1.1 If Yes, is there a 20 metre reserve along the stream for its entire length within the cutblock? ☐ Yes ☐ No

Description of reserve if less than 20 metres (e.g., size, characteristics)

14.1.2 Is there a management zone to protect the reserve from windthrow? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

14.1.3 Estimate the % of windthrow in the reserve:

Up to 5m from the bank: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

5m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

14.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed
% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

14.1.5 Are there any windthrown trees with roots embedded in the stream bank?
☐ Yes ☐ No

14.1.6 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Up to 5m from the bank: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

5m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

14.2 Is the stream being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

14.2.1 Estimate the % of windthrow in the management zone:

Up to 5m from the bank: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

5m to the end of the management zone: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

14.3 Were any strategies other than a reserve or a management zone utilized to manage the sinking stream? ☐ Yes ☐ No

If Yes, describe: _____

14.4 Is there evidence of stream bank disturbance due to forest practices along the length of the stream within the cutblock? ☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Type of disturbance: _____

14.5 Are there any sediment channels entering the stream from stream-side soil disturbance? ☐ Yes ☐ No

If the level of stream bank disturbance within the cutblock suggests that the significant downstream recipient karst feature may have been impacted (i.e., >15% disturbance), evaluation of the recipient karst feature may be required. If the recipient karst feature is evaluated, answer the following questions.

14.6 Are there any fine sediment deposits blanketing substrates in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.7 Is there an accumulation of needles, twigs or bark fragments in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.8 Is there a build-up of large and/or small woody debris in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.9 Based on the above observations, how effective have forest practices been in maintaining the water quality of the sinking/losing stream? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum 20-metre reserve with an adjacent management zone of an appropriate size to protect the reserve from windthrown or sinking/losing streams 1.0-3.0m wide on karst or 1.5-3.0m wide on non-karst that contribute water to a significant recipient karst feature located within 500m downstream of the cutblock boundary.

Woody debris (large and small), sediment, and organic material can be transported downstream where it accumulates and clogs recipient karst features such as swallets or cave entrances. This can restrict water from entering the subsurface and/or redirect flows to other subsurface openings or to the surface. Of particular concern is the introduction of fine sediment (e.g., silts, sands, clays) and fine organic material (e.g., needles, twigs, leaves) into subsurface cavities, including caves. Suspended or dissolved organic materials can coat underground surfaces, impacting subsurface habitats and other cave resources or values (e.g., mineral formations). These materials can coat underground surfaces, thereby impacting subsurface habitats and other cave resources or values (e.g., mineral formations). The slow decay rate associated with underground environments in British Columbia allows the organic component of this material to accumulate and persist over long periods of time. In addition, the decomposition of organic material can lower dissolved oxygen levels in karst waters.

Field Methodologies:

- Refer to the KFA to establish if there are any significant recipient karst features within the allocated distances downstream of the cutblock boundary.
- To estimate the average width of the sinking stream, measure bank-full cross sections at five locations spaced evenly along the reach within the cutblock boundary (i.e., at either edge of the cutblock and three additional locations distributed evenly, if the stream flows through the entire cutblock). Calculate the average width from the five measurements.
- Visually estimate the amount of windthrow/felled trees in the riparian reserve by traversing through the reserve on both sides of the stream. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used along the stream instead of the recommended reserve), traverse the management zone on both sides of the stream.
- To determine the amount of stream bank disturbance, walk the stream along its entire length within the cutblock boundary observing both banks for signs of bank erosion. Estimate the percentage of stream bank disturbance by totalling the length of disturbed sites versus the length of the stream within the cutblock boundaries.

- To establish the presence of sediment channels entering the stream, walk the stream along its entire length within the cutblock boundary observing both banks for signs of sediment channels flow into the stream.
- If stream bank disturbance within the cutblock is >15%, use KFA maps to determine the location of the downstream recipient karst feature in order to evaluate any potential impacts at the feature.
- The presence of fine sediment deposits; accumulations of needles, twigs or bark fragments; or a build-up of large and/or small woody debris at the recipient karst feature or just inside the feature indicates the transfer or potential transfer of sediments and organic matter into the subsurface karst environment.

Scenario#2:

14.10 Is the significant recipient karst feature located more than 500 metres downstream of the cutblock boundary? ☐ Yes ☐ No

If Yes:

14.10.1 Is there an appropriately sized riparian management zone along the stream for its entire length within the cutblock? ☐ Yes ☐ No

If Yes:

14.10.2 Size of riparian management zone: _____

14.11 Were windfirm non-merchantable trees, wildlife trees, and other vegetation (e.g., understory shrubs, herbs) retained within 5 m of the channel? ☐ Yes ☐ No

14.12 Have any trees with roots embedded in the bank been subjected to windthrow? ☐ Yes ☐ No

14.13 Is there any logging slash or debris in the channel? ☐ Yes ☐ No

14.14 Is there evidence of stream bank disturbance due to crossings, roads, trails, falling, yarding or other forest practices along the length of the stream within the cutblock?

☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Type of disturbance: _____

14.15 Are there any sediment channels entering the stream from stream-side soil disturbance? ☐ Yes ☐ No

If the level of stream bank disturbance within the cutblock suggests that the significant downstream recipient karst feature may have been impacted (i.e., >15% disturbance), evaluation of the recipient karst feature may be required. If the recipient karst feature is evaluated, answer the following questions.

14.16 Are there any fine sediment deposits blanketing substrates in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.17 Is there an accumulation of needles, twigs or bark fragments in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.18 Is there a build-up of large and/or small woody debris in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

14.19 Based on the above observations, how effective have forest practices been in maintaining the water quality of the sinking/losing stream? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends an appropriately sized riparian management zone for sinking/losing streams 1.0-3.0m wide on karst or 1.5-3.0m wide on non-karst that contribute water to a significant recipient karst feature located more than 500m downstream of the cutblock boundary. The handbook recommends the following practices within the riparian management zone to maintain the water quality of the sinking/losing stream:

- Retain windfirm trees with roots embedded in the bank;
- Fall and yard away to the fullest extent possible;
- Avoid cross-channel yarding;
- Remove slash and debris that inadvertently enters the channel;
- Retain windfirm non-merchantable trees and other windfirm vegetation (e.g., understory, shrubs, herbs) within five metres of the channel; and
- Retain windfirm wildlife trees.

Woody debris (large and small), sediment, and organic material can be transported downstream where it accumulates and clogs recipient karst features such as swallets or cave entrances. This can restrict water from entering the subsurface and/or redirect flows to other subsurface openings or to the surface. Of particular concern is the introduction of fine sediment (e.g., silts, sands, clays) and fine organic material (e.g., needles, twigs, leaves) into subsurface cavities, including caves. Suspended or dissolved organic materials can coat underground surfaces, impacting subsurface habitats and other cave resources or values (e.g., mineral formations). These materials can coat underground surfaces, thereby impacting subsurface habitats and other cave resources or values (e.g., mineral formations). The slow decay rate associated with underground environments in British Columbia allows the organic component of this material to accumulate and persist over long periods of time. In addition, the decomposition of organic material can lower dissolved oxygen levels in karst waters.

Field Methodologies:

- Refer to the KFA to establish if there are any significant recipient karst features within the allocated distances downstream of the cutblock boundary.
- To estimate the average width of the sinking stream, measure bank-full cross sections at five locations spaced evenly along the reach within the cutblock boundary (i.e., at either edge of the cutblock and three additional locations distributed evenly, if the stream flows through the entire cutblock). Calculate the average width from the five measurements.
- To determine the amount of stream bank disturbance, walk the stream along its entire length within the cutblock boundary observing both banks for signs of bank erosion. Estimate the percentage of stream bank disturbance by totalling the length of disturbed sites versus the length of the stream within the cutblock boundaries.
- To establish the presence of sediment channels entering the stream, walk the stream along its entire length within the cutblock boundary observing both banks for signs of sediment channels flow into the stream.
- If stream bank disturbance within the cutblock is >15%, use KFA maps to determine the location of the downstream recipient karst feature in order to evaluate any potential impacts at the feature.
- The presence of fine sediment deposits; accumulations of needles, twigs or bark fragments; or a build-up of large and/or small woody debris at the recipient karst feature or just inside the feature indicates the transfer or potential transfer of sediments and organic matter into the subsurface karst environment.

Section – 15 - If the stream is >3.0m wide on karst or non-karst:

Evaluation Question: Has the water quality of the sinking/losing stream been maintained?

Width of stream (metres): _____

15.1 Is there a significant recipient karst feature located any distance downstream of the cutblock boundary? ☐ Yes ☐ No

15.1.1 If Yes, is there a 20 metre reserve along the stream for its entire length within the cutblock? ☐ Yes ☐ No

Description of reserve if less than 20 metres (e.g., size, characteristics)

15.1.2 Is there a management zone to protect the reserve from windthrow? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

☐ Other: _____

☐ No Treatment

15.1.3 Estimate the % of windthrow in the reserve:

Up to 5m from the bank: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

5m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

15.1.4 Distribution of windthrow in the reserve: ☐ N/A ☐ localized ☐ dispersed
% of leading edge affected: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

15.1.5 Are there any windthrown trees with roots embedded in the stream bank?

☐ Yes ☐ No

15.1.6 Have trees in the reserve been felled? ☐ Yes ☐ No

If Yes, estimate the amount:

Up to 5m from the bank: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

5m to 20m: ☐ <5% ☐ 5-15% ☐ 15-30% ☐ >30%

15.2 Is the stream being managed with a management zone only? ☐ Yes ☐ No

If Yes, describe the management zone (e.g., size, shape, vegetation):

Identify any treatments in the management zone:

☐ Feathering

☐ Topping

- ☐ Other: _____
☐ No Treatment

15.2.1 Estimate the % of windthrow in the management zone:

Up to 5m from the bank: ☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%
5m to the end of the management zone: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

15.3 Were any strategies other than a reserve or a management zone utilized to manage the sinking stream? ☐ Yes ☐ No

If Yes, describe: _____

15.4 Is there evidence of stream bank disturbance due to forest practices along the length of the stream within the cutblock? ☐ Yes ☐ No

If Yes, estimate the amount: ☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

Type of disturbance: _____

15.5 Are there any sediment channels entering the stream from stream-side soil disturbance? ☐ Yes ☐ No

If the level of stream bank disturbance within the cutblock suggests that the significant downstream recipient karst feature may have been impacted (i.e., >15% disturbance), evaluation of the recipient karst feature may be required. If the recipient karst feature is evaluated, answer the following questions.

15.6 Are there any fine sediment deposits blanketing substrates in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

15.7 Is there an accumulation of needles, twigs or bark fragments in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

15.8 Is there a build-up of large and/or small woody debris in the channel bed at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

15.9 Based on the above observations, how effective have forest practices been in maintaining the water quality of the sinking/losing stream? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends a minimum 20-metre reserve with an adjacent management zone of an appropriate size to protect the reserve from windthrown for sinking/losing streams >3.0m wide on karst or non-karst that contribute water to a significant recipient karst feature located any distance downstream of the cutblock boundary.

Woody debris (large and small), sediment, and organic material can be transported downstream where it accumulates and clogs recipient karst features such as swallets or cave entrances. This can restrict water from entering the subsurface and/or redirect flows to other subsurface openings or to the surface. Of particular concern is the introduction of fine sediment (e.g., silts, sands, clays) and fine organic material (e.g., needles, twigs, leaves) into subsurface cavities, including caves. Suspended or dissolved organic materials can coat underground surfaces, impacting subsurface habitats and other cave resources or values (e.g., mineral formations). These materials can coat underground surfaces, thereby impacting subsurface habitats and other cave resources or values (e.g., mineral formations). The slow decay rate associated with underground environments in British Columbia allows the organic component of this material to accumulate and persist over long periods of time. In addition, the decomposition of organic material can lower dissolved oxygen levels in karst waters.

Field Methodologies:

- Refer to the KFA to establish if there are any significant recipient karst features within the allocated distances downstream of the cutblock boundary.
- To estimate the average width of the sinking stream, measure bank-full cross sections at five locations spaced evenly along the reach within the cutblock boundary (i.e., at either edge of the cutblock and three additional locations distributed evenly, if the stream flows through the entire cutblock). Calculate the average width from the five measurements.
- Visually estimate the amount of windthrow/felled trees in the riparian reserve by traversing through the reserve on both sides of the stream. Estimating the % of leading edge affected by windthrow can be visually estimated by walking the perimeter of the reserve and comparing the amount of edge windthrow with the total amount of windthrow in the reserve.
- To estimate the amount of windthrow/felled trees in a management zone (if a management zone is used along the stream instead of the recommended reserve), traverse the management zone on both sides of the stream.
- To determine the amount of stream bank disturbance, walk the stream along its entire length within the cutblock boundary observing both banks for signs of bank erosion. Estimate the percentage of stream bank disturbance by totalling the length of disturbed sites versus the length of the stream within the cutblock boundaries.
- To establish the presence of sediment channels entering the stream, walk the stream along its entire length within the cutblock boundary observing both banks for signs of sediment channels flow into the stream.
- If stream bank disturbance within the cutblock is >15%, use KFA maps to determine the location of the downstream recipient karst feature in order to evaluate any potential impacts at the feature.
- The presence of fine sediment deposits; accumulations of needles, twigs or bark fragments; or a build-up of large and/or small woody debris at the recipient karst

feature or just inside the feature indicates the transfer or potential transfer of sediments and organic matter into the subsurface karst environment.

Section 16 - Sinking Watercourses Contributing Water to a Significant Recipient Karst Feature

Evaluation Question: Has the water quality of the sinking watercourse been maintained?

Width of watercourse (metres): _____

16.1 Are windfirm trees with roots embedded in the watercourse edge retained?

☐ Yes ☐ No

16.2 Are windfirm non-merchantable trees, wildlife trees, and other vegetation (e.g., understorey shrubs, herbs) retained within 5 m of the watercourse edge?

☐ Yes ☐ No

16.3 Is there any logging slash and/or road construction debris in the watercourse?

☐ Yes ☐ No

16.4 Are there any fine sediment deposits at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

16.5 Is there an accumulation of needles, twigs or bark fragments at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

16.6 Is there a build-up of large and/or small woody debris at the recipient karst feature or just inside the feature? ☐ Yes ☐ No

16.7 Based on the above observations, how effective have forest practices been in maintaining the water quality of the sinking watercourse?

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The *Karst Management Handbook for British Columbia* recommends an appropriately sized riparian management zone for sinking watercourses that contribute water to a significant recipient karst feature located. The riparian management zone should extend a minimum of 100m upstream of the recipient karst feature or to the point where the watercourse is no longer readily identifiable, whichever is shorter. The handbook recommends the following practices within the riparian management zone to maintain the water quality of the sinking watercourse:

- Retain windfirm trees with roots embedded in the watercourse edge;
- Fall and yard away from the watercourse to the fullest extent possible;
- Avoid yarding across the watercourse;
- Remove slash and debris that inadvertently enter the watercourse;
- Retain windfirm non-merchantable trees and other windfirm vegetation (e.g., understory, shrubs, herbs) within five metres of the watercourse edge; and
- Retain windfirm wildlife trees.

Woody debris (large and small), sediment, and organic material can be transported downstream where it accumulates and clogs recipient karst features such as swallets or cave entrances. This can restrict water from entering the subsurface and/or redirect flows to other subsurface openings or to the surface. Of particular concern is the introduction of fine sediment (e.g., silts, sands, clays) and fine organic material (e.g., needles, twigs, leaves) into subsurface cavities, including caves. Suspended or dissolved organic materials can coat underground surfaces, impacting subsurface habitats and other cave resources or values (e.g., mineral formations). These materials can coat underground surfaces, thereby impacting subsurface habitats and other cave resources or values (e.g., mineral formations). The slow decay rate associated with underground environments in British Columbia allows the organic component of this material to accumulate and persist over long periods of time. In addition, the decomposition of organic material can lower dissolved oxygen levels in karst waters.

Field Methodologies:

- The questions in this section can be answered directly through field observations.
- The presence of fine sediment deposits; accumulations of needles, twigs or bark fragments; or a build-up of large and/or small woody debris at the recipient karst feature or just inside the feature indicates the transfer or potential transfer of sediments and organic matter into the subsurface karst environment.

Part D – Broad Karst Landscape

Section 17 - Roads, Landings and Quarries on Moderate Vulnerability Karst

Evaluation Question: Has the impact of roads, landings and quarries been minimized on moderate vulnerability karst?

17.1 Were existing roads, landings and quarries utilized in preference to building new ones? ☐ Yes ☐ No ☐ N/A

Comments _____

17.2 Were deep cuts and fills minimized? ☐ Yes ☐ No

Comments _____

17.3 Were disturbed areas (e.g., quarries, borrow pits, cut and fill slopes) left in a stable condition to reduce the potential for soil erosion? ☐ Yes ☐ No

Comments _____

17.4 Is surface runoff from roads, landings, quarries and bridge decks directed to infiltration areas with sufficient vegetation and soil cover and/or sediment traps to prevent sediment-laden runoff from contaminating karst waters? ☐ Yes ☐ No

Comments _____

17.5 Based on the above observations, how effective have forest practices been in minimizing the impact of roads, landings and quarries on moderate vulnerability karst?

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The construction of roads, landings and quarries on moderate and high vulnerability karst has the potential to significantly impact surface and subsurface karst features in a number of ways. Features can be physically damaged by construction activities, the risk of soil erosion and sediment transfer to the subsurface is high, natural surface and subsurface drainage patterns can be disrupted, and surface and subsurface water quality can be impacted by runoff from roads, landings or quarries.

A major area of potential conflict with road locations on karst landscapes is the fact that logging roads are often located along ridges and areas of higher elevation for effective access to timber. These same locations are also where the greatest density of exposed epikarst is typically found. In many cases, viable alternative locations for the road are not available, and the roads must be constructed carefully to minimize impacts to the epikarst as much as possible. For these reasons and others, the area occupied by roads, landing and quarries in moderate and high vulnerability karst should be minimized as

much as possible. Construction methods should focus on minimizing the potential for soil erosion and sediment transfer to the subsurface.

Field Methodologies:

- Many of the questions in this section can be answered by consulting the KFA report for the area. Other questions are answered directly through field observations.

Section 18 - Roads, Landings and Quarries on High Vulnerability Karst

Evaluation Question: Has the impact of roads, landings and quarries been minimized on high vulnerability karst?

18.1 Did mainline roads and landings avoid well-developed epikarst exposures as much as possible? ☐ Yes ☐ No ☐ unknown

Comments _____

18.2 Did road building minimize damage to well-developed epikarst exposures as much as possible? ☐ Yes ☐ No ☐ unknown

Comments _____

18.3 Were specialized road building techniques used when crossing segments of well-developed epikarst exposures? ☐ Yes ☐ No ☐ unknown

If Yes, indicate the techniques that were used:

- ☐ Overlanding construction methods (e.g., minimal grubbing, flush-cut stumps, etc.)
- ☐ Minimal clearing widths, road widths and landing areas
- ☐ Large ballast material
- ☐ Avoiding the use of fines on road surfaces
- ☐ Use of geotextiles to minimize sediment transfer
- ☐ Use of bridging mechanisms (e.g., geogrids, stringer bridges) for spanning epikarst cavities/features
- ☐ Other (describe): _____

18.4 Were quarries located on nearby low and moderate vulnerability karst rather than on high vulnerability karst? ☐ Yes ☐ No ☐ unknown

Comments _____

18.5 Based on the above observations, how effective have forest practices been in minimizing the impact of roads, landings and quarries on high vulnerability karst?

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

The construction of roads, landings and quarries on moderate and high vulnerability karst has the potential to significantly impact surface and subsurface karst features in a number of ways. Features can be physically damaged by construction activities, the risk of soil erosion and sediment transfer to the subsurface is high, natural surface and subsurface drainage patterns can be disrupted, and surface and subsurface water quality can be impacted by runoff from roads, landings or quarries.

A major area of potential conflict with road locations on karst landscapes is the fact that logging roads are often located along ridges and areas of higher elevation for effective access to timber. These same locations are also where the greatest density of exposed

epikarst is typically found. In many cases, viable alternative locations for the road are not available, and the roads must be constructed carefully to minimize impacts to the epikarst as much as possible. For these reasons and others, the area occupied by roads, landing and quarries in moderate and high vulnerability karst should be minimized as much as possible. Construction methods should focus on minimizing the potential for soil erosion and sediment transfer to the subsurface.

Specialized road building techniques should be used to reduce impacts when crossing sections of well-developed epikarst exposures, including:

- Overlanding construction methods (e.g., minimal grubbing, flush-cut stumps, etc.);
- Minimal clearing widths, road widths and landing areas;
- Large ballast material;
- Avoiding the use of fines on road surfaces;
- Use of geotextiles to minimize sediment transfer; and
- Use of bridging mechanisms (e.g., geogrids, stringer bridges) for spanning epikarst cavities/features.

Field Methodologies:

- Many of the questions in this section can be answered by consulting the KFA report for the area. Other questions are answered directly through field observations.

Section 19 - Timber Harvesting on Moderate Vulnerability Karst

Evaluation Question: Have the impacts of timber harvesting been minimized on moderate vulnerability karst?

19.1 Were natural surface drainage patterns maintained during harvesting operations?

☐ Yes ☐ No

19.2 Did forest practices minimize dispersed soil disturbance as much as possible?

☐ Yes ☐ No

If Yes, identify the types of forest practices:

☐ Maximum suspension yarding

☐ Rubber mats

☐ Other (describe): _____

☐ Unknown

19.3 Estimated level of dispersed soil disturbance on moderate vulnerability karst:

☐ <5% ☐ 5-15% ☒ 15-30% ☐ >30%

19.4 Based on the above observations, how effective have forest practices been in minimizing harvesting impacts on moderate vulnerability karst? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

A major management objective when harvesting timber on moderate and high vulnerability karst is to minimize the disturbance of sensitive karst soils to prevent soil erosion and potential sediment transfer into subsurface karst environments. The potential for rapid vertical transfer of large quantities of soil into epikarst cavities or other subsurface openings is a management concern unique to three-dimensional karst landscapes. Significant soil erosion can occur on even gentle slopes or flat terrain with well-developed epikarst, where no erosion problems would be anticipated on a non-karst landscape of similar slope.

Field Methodologies:

- Use KFA maps to identify the moderate vulnerability karst areas within the cutblock.
- To estimate the percentage of dispersed soil disturbance by vulnerability class, total the amount of disturbance within the specified vulnerability class versus the total area occupied by that vulnerability class.

Section 20 - Timber Harvesting on High Vulnerability Karst

Evaluation Question: Have the impacts of timber harvesting been minimized on high vulnerability karst?

20.1 Did forest practices minimize dispersed soil disturbance as much as possible?

☐ Yes ☐ No

If Yes, identify the types of forest practices:

- ☐ Heli-logging
- ☐ Partial cutting
- ☐ Maximum or total suspension yarding
- ☐ Rubber mats
- ☐ Other (describe): _____
- ☐ Unknown

20.2 Estimated level of dispersed soil disturbance on high vulnerability karst:

☐ <5% ☒ 5-15% ☐ 15-30% ☐ >30%

20.3 Were any well-developed epikarst exposures physically damaged during harvesting operations (e.g., broken or crushed surfaces)? ☐ Yes ☐ No

20.3.1 If Yes, estimate the amount of damage: ☐ Low ☒ Moderate ☐ High

Where:

Low = nil to minimal damage to epikarst exposures

Moderate = damage to epikarst exposures occurs at more than one site

High = damage to epikarst exposures is widespread

20.4 Is there evidence of soil loss/sediment transfer into epikarst cavities as a result of timber harvesting? ☐ Yes ☐ No

20.4.1 If Yes, estimate the amount of soil loss/sediment transfer:

☐ low ☒ moderate ☐ high

Where:

Low = nil to trace amounts of soil/sediment in epikarst cavities

Moderate = measurable amounts of soil/sediment in epikarst cavities occur at more than one site

High = soil loss/sediment transfer in epikarst cavities is widespread

20.5 Is there any logging debris in epikarst cavities? ☐ Yes ☐ No

20.5.1 If Yes, estimate the amount of logging debris: ☐ low ☒ moderate ☐ high

Where:

Low = nil to trace amounts of logging debris in epikarst cavities

Moderate = measurable amounts of logging debris in epikarst cavities occur at more than one site

High = logging debris in epikarst cavities is widespread

20.6 Is there any evidence of burning slash on epikarst exposures? ☐ Yes ☐ No

20.7 Based on the above observations, how effective have forest practices been in minimizing harvesting impacts on moderate and high vulnerability karst? (Shaded areas are generally above acceptable thresholds.)

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

A major management objective when harvesting timber on moderate and high vulnerability karst is to minimize the disturbance of sensitive karst soils to prevent soil erosion and potential sediment transfer into subsurface karst environments. The potential for rapid vertical transfer of large quantities of soil into epikarst cavities or other subsurface openings is a management concern unique to three-dimensional karst landscapes. Significant soil erosion can occur on even gentle slopes or flat terrain with well-developed epikarst, where no erosion problems would be anticipated on a non-karst landscape of similar slope.

When harvesting timber on exposed, well-developed epikarst exposures, the management objectives are to avoid physically damaging the epikarst with machinery or falling large timber, prevent soil loss/sediment transfer into epikarst cavities and the subsurface, and keep epikarst cavities free of logging debris to maintain the connectivity between the surface and subsurface.

Burning slash on well-developed epikarst exposures can destroy the typically thin, organic soil layer, physically alter the epikarst, and clog epikarst cavities with charred wood remains, which can disrupt the connectivity between the surface and subsurface.

Field Methodologies:

- Use KFA maps to identify the high vulnerability karst areas within the cutblock.
- To estimate the percentage of dispersed soil disturbance by vulnerability class, total the amount of disturbance within the specified vulnerability class versus the total area occupied by that vulnerability class.

Section 21 - Very High Vulnerability Karst

Evaluation Question: Has the integrity of very high vulnerability karst been protected?

21.1 Were any new roads, landings or quarries constructed on very high vulnerability karst? ☐ Yes ☐ No

Comments _____

21.2 Did any timber harvesting occur on very high vulnerability karst other than that required to protect at risk forest or karst resources (e.g., to address forest health issues)?

☐ Yes ☐ No

Comments _____

21.3 Based on the above observations, has the integrity of very high vulnerability karst areas been protected?

☐ not at all ☐ poor ☐ moderately effective ☐ very effective

Comments: _____

Rationale:

Very high vulnerability karst areas are particularly sensitive to disturbance due to thin organic soils, intense epikarst development, and generally steeper slopes. The *Karst Management Handbook for British Columbia* recommends that very high vulnerability areas be excluded from harvesting operations except in special situations where some form of site-specific intervention is required to help protect at risk forest or karst resources (e.g., forest health issues)

Field Methodologies:

- The questions in this section can be answered by consulting the KFA report for the area, or directly through field observations.