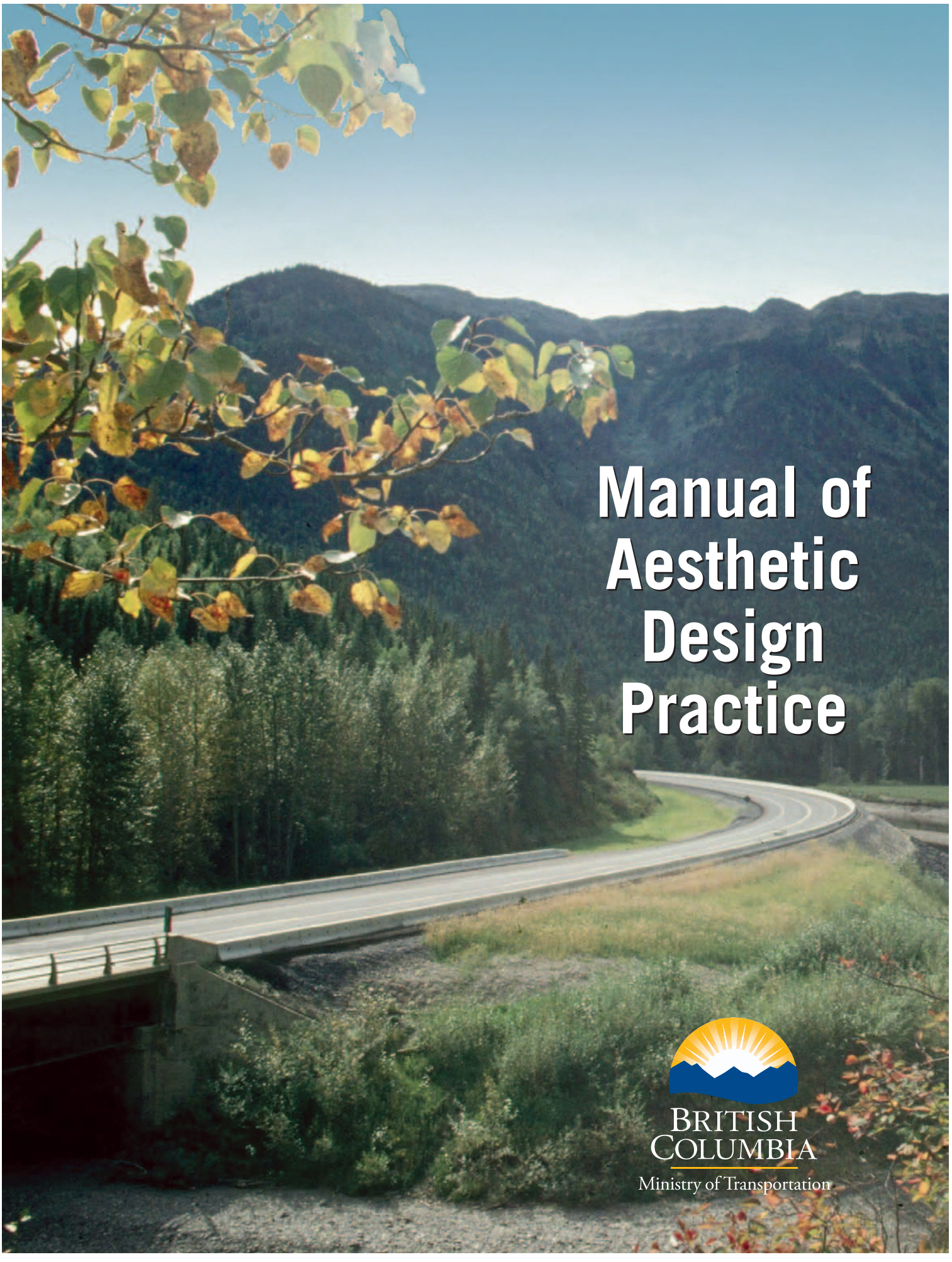

Manual of Aesthetic Design Practice

BRITISH COLUMBIA
Ministry of Transportation

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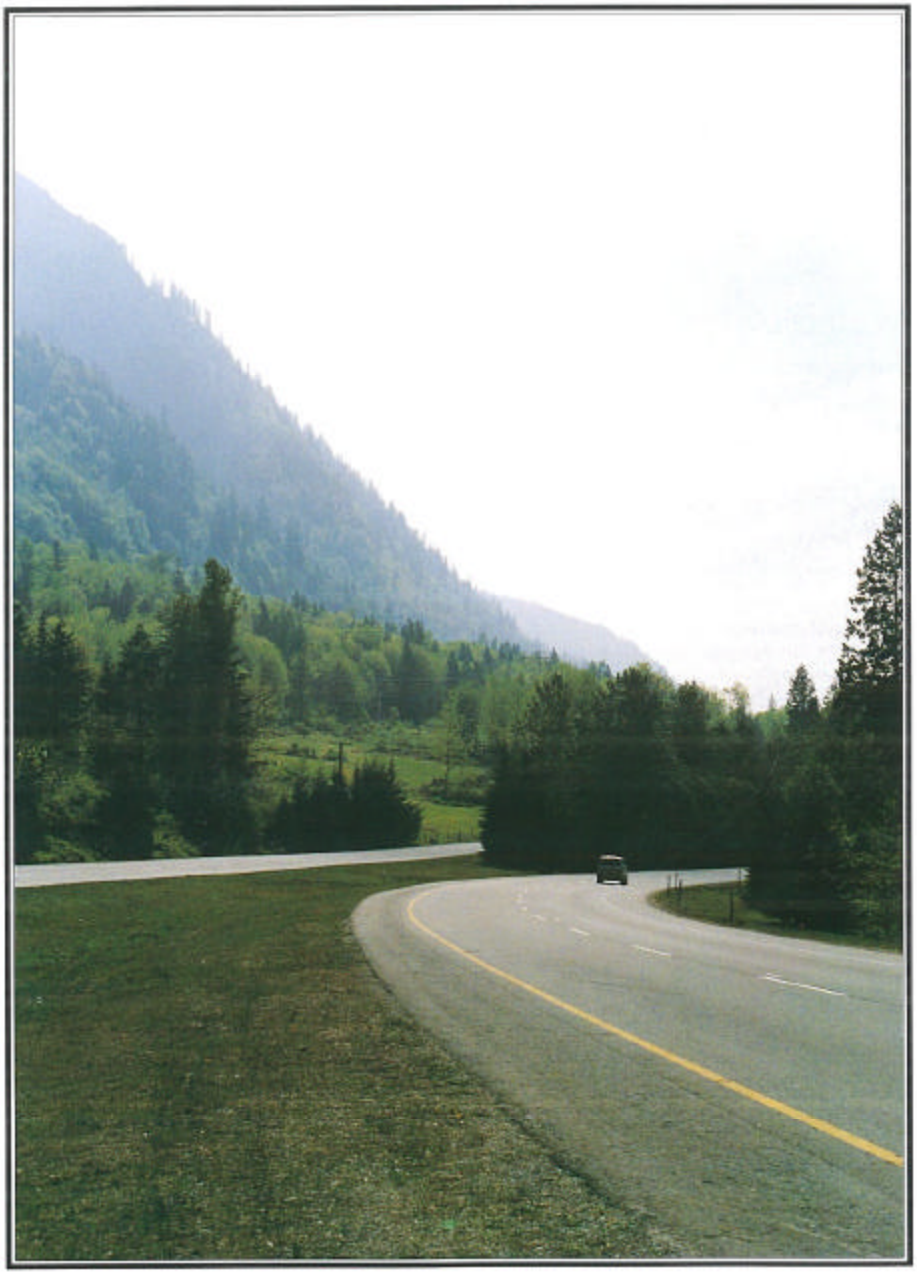

Alignment

Alignment

Introduction

Pleasant and graceful highways rely heavily on well designed roadway alignments. Alignment is one of the most complex aspects of highway design involving the elegant resolution of numerous and often contradictory pressures.

Successful alignment requires the integration of horizontal and vertical curvature to create a fluid, comfortable and safe driving experience.

Alignment choices must respond to the adjacent topography, acknowledging significant landmarks and respecting the presence of fragile valleys and shorelines. Alignments which minimize their impact on the surrounding landscape will reduce visible scars, as well as construction and maintenance costs.

For the driver a well designed highway alignment will result in a pleasant, visually stimulating, and safe driving experience. Varied medians should be considered, and when developed in response to landform or other considerations should make sense from behind the steering wheel, as comfortable responses to topography and vegetation.

Alignment can have a dramatic influence on the driver's experience by revealing views toward waterbodies or valleys, at the same time withholding views toward negative features such as forestry clearcuts and cleared utility corridors.

The following section outlines specific recommendations which when considered together will direct the evolution of highway alignment toward this goal of ingeniously simple and beautiful solutions.

Recommended Practices

The following pages outline recommended practices concerning the aesthetic alignment of highways in B.C. These practices are summarized below.

1.0 Design roadway alignments as one integrated and co-coordinated blend of vertical alignment, and horizontal alignment, with consideration to the inclusion and variable width of the median.

2.0 Respond to the topography of the site.

3.0 Increase the level of interest of the driver and therefore the driver's attentiveness, safety and enjoyment.

4.0 Minimize confusing and erratic changes in alignment.

5.0 Provide safe decision and stopping sight distances to maintain the aesthetic experience of the driver.

6.0 Evaluate existing and potential views from the road to its surroundings and to the road itself.

7.0 Retain existing vegetation wherever feasible to mitigate an alignment's impact and therefore enhance the driver's experience.

8.0 Minimize the aesthetic consequences of adverse climatic conditions.

9.0 Consider potential aesthetic responses to negative ecological impacts attributed to road alignment.

10.0 Consider responses to aesthetic impacts directly attributed to land use changes caused by road alignment.

1.0 Integration of Alignment

Design roadway alignments as one integrated and co-coordinated blend of vertical alignment, and horizontal alignment, with consideration as to the inclusion and variable width of the median.

.1 Integrate the alignment of horizontal and vertical curves.

- Align vertical and horizontal curves with co-incident midpoints.
- Maintain similar approximate length in horizontal and vertical curves.
- Where vertical and horizontal curves coincide the horizontal curve should lead.

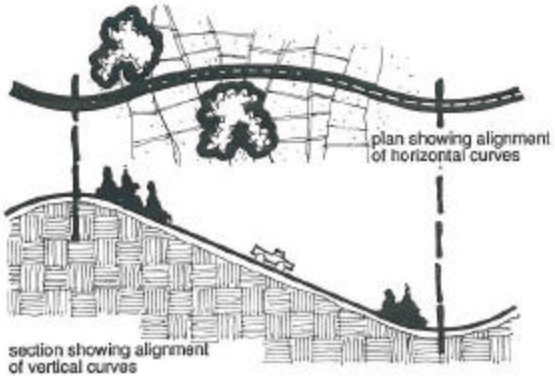

Figure D-1
Align vertical and horizontal curves with co-incident midpoints.

Figure D-2
Where vertical and horizontal curves do not coincide the vertical curves should lead.

.2 Where changes in direction are appropriate, design horizontal and vertical alignments as a series of long arcs with limited or no connecting tangents.

.3 On divided highways use independent vertical and horizontal alignments where advantageous.

**refer to EARTHWORKS and VEGETATIVE MANAGEMENT for implications of alignment adjustments and screening of views.*

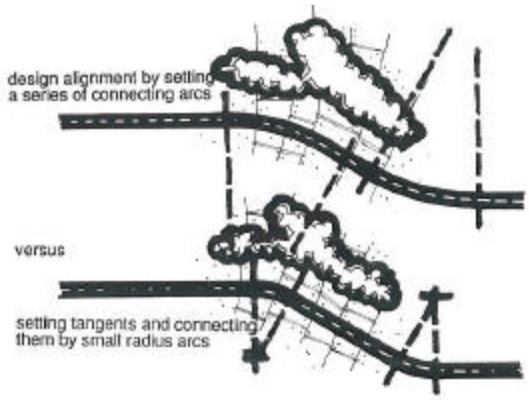

Figure D-3
Arc and spiral highway design.

Figure D-4
Consider separate alignments for divided highways

2.0 Response to Topography

Design the length of curves, tangents and changes in response to existing topography, landmarks, vegetation, and land use patterns. The response to topography requires different practices for different terrain as illustrated for the following special conditions.

.1 Flat Terrain

- On flat terrain (less than 5% slope), make long tangents predominate. Where strong land use pattern exists, align tangents with, and change direction in response to pattern.
- Where strong land use pattern is **not** present, focus alignment on natural or created landmarks such as mountain peaks, hills, water bodies, islands, significant tree specimens, shelterbelts, or buildings.
- Change direction in response to natural features. Withhold change of direction in response to large topographic features until within 5.0 km. Withhold change in direction in response to landmark trees and buildings until within 1.5 km.
- Change alignment or direction to skirt marsh, fen, kame and kettle, bog agricultural and forest clearings.

Figure D-5
Align tangents with land use and vegetation grid.

Figure D-6
Tangents should focus on natural or man-made landmarks.

Figure D-7
Ideal angle and distance from landmark.

Figure D-8
Skirt the edge of clearings and sensitive areas.

.2 Steep Terrain

- Align road along the contact between scree slopes and vertical rock face.
- Shape rock cuts and blasted areas to simulate adjacent landscape character.
- Earthworks at the skyline should reflect surrounding topography.
- Use separate terraced alignments and fill slopes to reduce cut and fill requirements to facilitate revegetation.
- Minimize the visual impact of traversing hillsides by running along the contour and responding to vegetation patterns.
- Ascend hills with minimum visibility from adjacent areas.*
- When traversing hillsides consider bridging gullies to reduce visible fill slope scars.

** refer to EARTHWORK and ROADWAY STRUCTURES (Retaining Wall).*

Figure D-9
Align roadway at the margin between scree slopes and vertical rock face.

Figure D-10
Terraced cut slopes allow for subsequent revegetation.

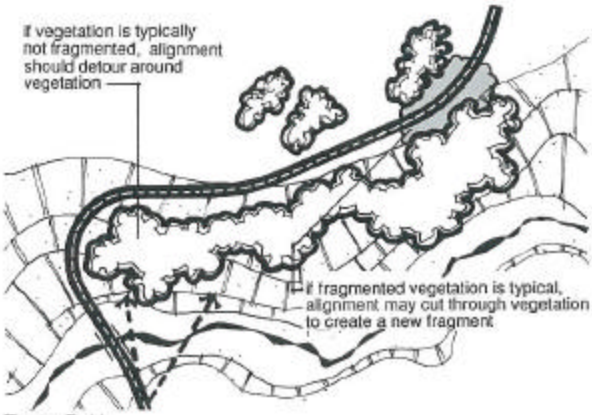

Figure D-11
Respond to vegetation patterns while traversing hillsides.

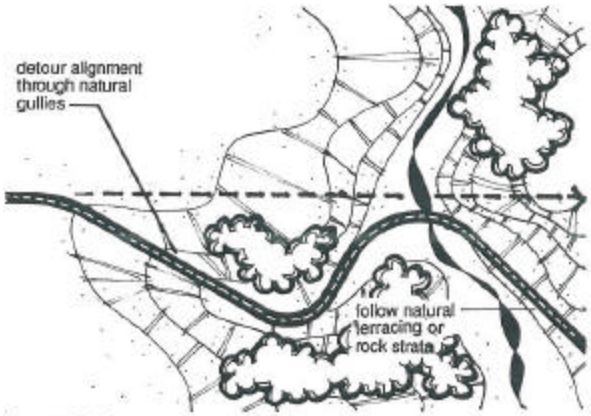

Figure D-12
Align road through natural gullies or created breaks to follow natural terracing or linear rock strata.

.3 Oceans, Lakes and Reservoirs

- Minimize the requirement for realignment, and regrading to natural shoreline.*
- Take advantage of potential views from road and roadside facilities.
- Provide mitigating measures when encroachment at water bodies is unavoidable.

*refer to EARTHWORKS and ROADWAY STRUCTURES (Retaining Walls)

Figure D-13
The view to adjacent water bodies can substantially enhance the driving experience.

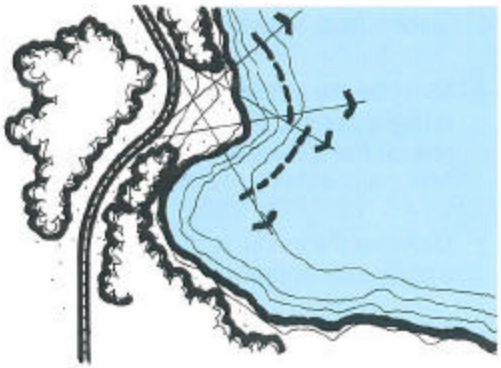

Figure D-14
Views from the roadway can be accommodated without impacting the shoreline.

Figure D-15
Where roadway alignments do impact on waterbodies aesthetics of shoreline treatment should be given a high priority.

.4 Rivers and Streams

- Minimize the requirement for channelization, realignment and regrading of natural banks to reduce the impact on natural watercourses and limit the possibility of subsequent erosion.*
- Minimize the amounts of highway runoff flowing directly into natural watercourses.
- Do not allow the right-of-way clearing to visually dominate the natural open space dimensions along the watercourse.
- Provide an advance view of bridges, then withhold view until bridge.**
- Design bridges as an extension of the horizontal and vertical curvature of adjacent sections of the roadway.
- Design bridges to be visually interesting and in context with the surrounding landscape character.

refer to EARTHWORKS and HIGHWAY STRUCTURES (Retaining Walls)

**refer to ROADWAY STRUCTURES (Bridges and Overpasses), EARTHWORKS and VEGETATIVE MANAGEMENT for integration with topography and vegetation.*

Figure D-16
Do not encroach on water bodies closer than 7.5 metres. This roadway would be better with a vegetated buffer between it and the river.

Figure D-17
In this example care has been taken to preserve the vegetated edge adjacent to the lake.

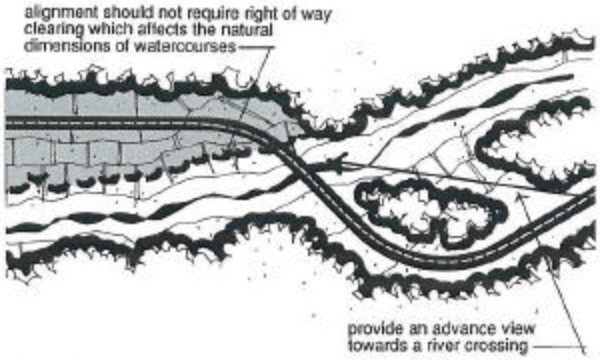

Figure D-18
Roadway alignment should not require clearing which overwhelms the natural dimensions of waterbodies.

Figure D-19
Bridges should become an extension of the curvilinear alignment of adjacent roadways.

.5 Valleys and Ravines

- Make a transitional descent into valleys and ravines.
- Make perceivable response in horizontal and vertical alignment to valley, gully, or swale.
- Make bridges and their approaches a continuation of the adjacent alignment.

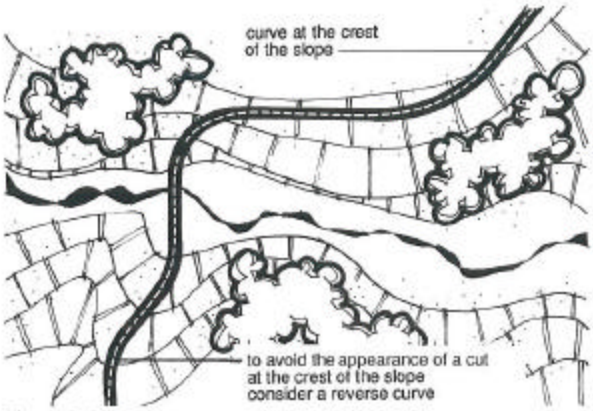

Figure D-20
Align road through natural gullies or created breaks.

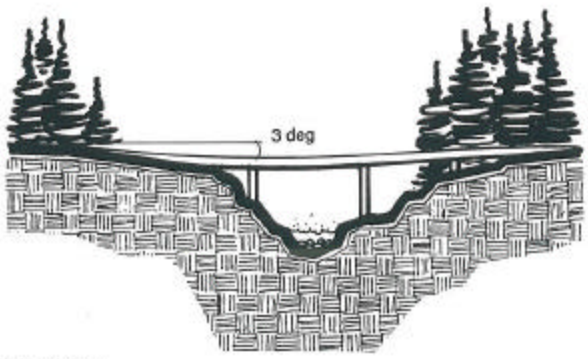

Figure D-21
Angle the vertical approach into the valley at a minimum of 3 degrees, to show a perceivable response to the valley.

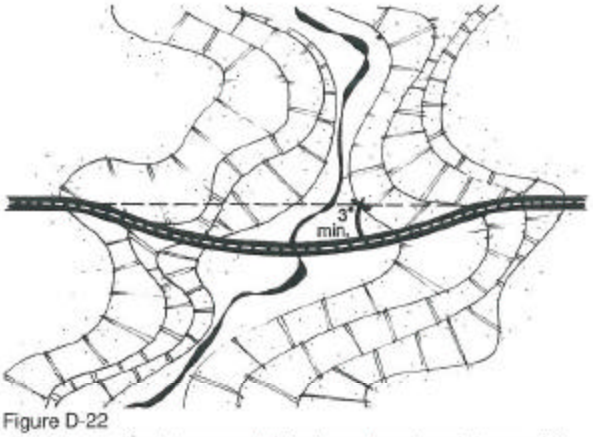

Figure D-22
Angle the horizontal approach into the valley at a minimum of 3 degrees, to expose views away from the road to the valley length and walls.

Figure D-23
Bridges should be designed as part of the horizontal and vertical alignment of the adjacent road. This straight bridge interrupts an otherwise graceful curvilinear alignment.

3.0 Driver Interest and Experience

Increase the level of interest of the driver and therefore the driver's attentiveness, safety and enjoyment.

.1 Align the highway to offer a variety of views, points of reference and surroundings to maintain the interest and attentiveness of the driver.*

- Locate some form of roadside facility to enable a driver to leave vehicle once every 1 hour driving time at the design speed.
- Provide a reason for renewed visual interest approximately every 5 minutes in the driver's experience.
- Consider inclusion of, or variation in, width of median.

**refer to VISUAL RESOURCE MANAGEMENT for additional detail on Driver's Experience.*

Figure D-24
Focus on landmarks such as mountains, predominant hills, landmark trees, forests, shelterbelts, and/or landmark buildings.

Figure D-25
Cross the edges of landscape units as this highway does passing from a forested area in the foreground, to an open grassland, and back into the forest in the distance.

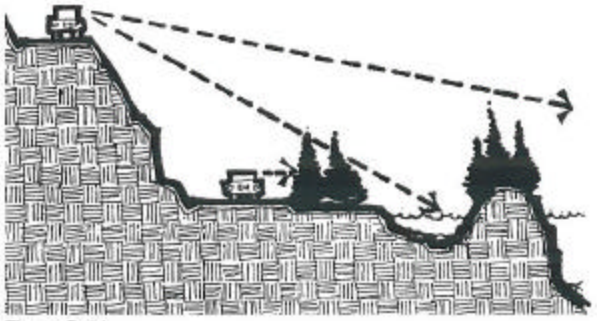

Figure D-26
Alternate between a sense of enclosure and long distance views (eg. forest vs. agricultural clearings, or tree groupings within a predominantly open landscape.)

Figure D-27
A varied median width can be used to enhance the driver's interest and attentiveness.

4.0 Confusing Alignment

Minimize confusing and erratic changes in alignment.

.1 Make horizontal alignment straightforward and responsive to context.

- Change direction in response to visual features, so as to avoid the appearance of sudden unexpected turns.
- Provide an intermediate transitional curve from tangents to horizontal curves.
- Co-ordinate vertical and horizontal curves to best display the road ahead to the driver.
- Limit the view of the road ahead within the area of effective vision to no more than three changes in alignment.

Figure D-28
Alignment should change in response to significant visual features

Figure D-29
Limit the view of the road ahead within the area of effective vision to no more than three changes in alignment.

.2 The design of vertical alignments can contribute to a readily comprehensible roadway.

- Avoid a repetitious sequence of vertical curves giving the impression of a roller coaster.
- Avoid sharp sags in the road which may obscure the view of oncoming traffic for brief periods.
- Design vertical curves at lengths approximating the limits of effective vision.

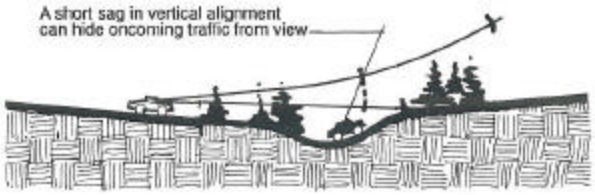

Figure D-30
Avoid short vertical curves which may obscure the view to oncoming traffic.

Figure D-31
In this photograph signs have been erected to warn motorists of restricted visibilty as a result of a short vertical curvature.

Figure D-32
Avoid a sequence of grade changes which may appear as a roller coaster.

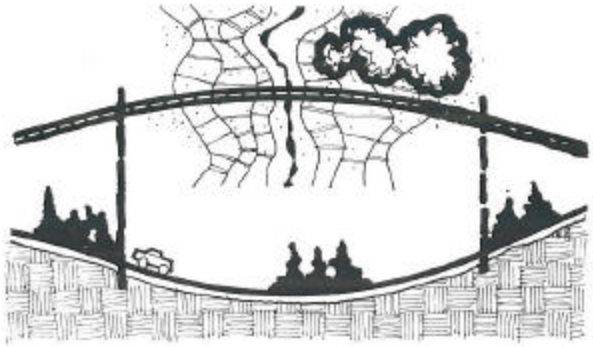

Figure D-33
Vertical (sag) curve should approximate horizontal curve length.

Figure D-34
Vertical curve length should approximate length of effective vision.

.4 Eliminate confusing relationships between alignments and between highway and frontage roads.

- Provide a visual screen of earthwork or vegetation.
- Screen and lengthen horizontal curves where alignments converge.
- Avoid deceptive clearings from appearing at the end of tangents.

Figure D-35
Provide a visual screen between frontage roads and highways.

Figure D-36
Align roads to avoid clearings at the ends of tangents.

5.0 Safety

Provide for safe sight distances, adequate protection against headlight glare, and safety recovery areas to minimize stress to the driver.

.1 Pay attention to safe sight distances to access/egress points, safety signage, and passing zones.

- Provide safe decision sight distances at approaches to interchanges.
- Provide safe decision sight distances at passing zones.
- Provide safe decision and stopping sight distances at approaches to intersections.
- Provide safe decision and stopping sight distances at approaches to roadside facilities.
- Provide safe decision and stopping sight distances at signage.

Minimum stopping sight distance

design speed km/h	design values for minimum stopping sight distance m
40	45
50	65
60	85
70	110
80	140
90	170
100	200
110	220
120	240
130	260

Figure D-37
Indicates minimum stopping sight distances at various design speeds. (Taken from RTAC)

Note: For additional information refer to the Roads and Transportation Association of Canada's (RTAC) Manual of Geometric Design Standards for Canadian Roads, and Province of British Columbia's Highway Design Manual of Standards and Instructions for existing or revised safe sight distance.

.2 Alignment should include space to allow traffic leaving the highway to stop safely.

- Roadway cross sections should allow for a safety recovery zone with a gradual slope adjacent to traffic lanes.
- Cross sections should also include medians with shrub planting to safely slow the progress of traffic leaving the highway.

Figure D-38
The grassed safety recovery area at the edge of this roadway is provided to allow vehicles to make emergency stops. Typically these areas will not have slopes exceeding 5:1.

Figure D-39
Shrubs used for median planting can provide an additional measure of crash protection.

.3 Provide adequate protection against the glare of oncoming headlights.

- For divided highways minimize the occurrence of convergent alignments.
- Where convergent alignments cause headlights to shine into the path of oncoming traffic the impact can be minimized by any, or a combination of the following:
  - a bermed median.
  - ambient/background lighting.
  - vegetative screen with maximum density between 0.3m and 1.3m height.
  - a light diffusing fence.

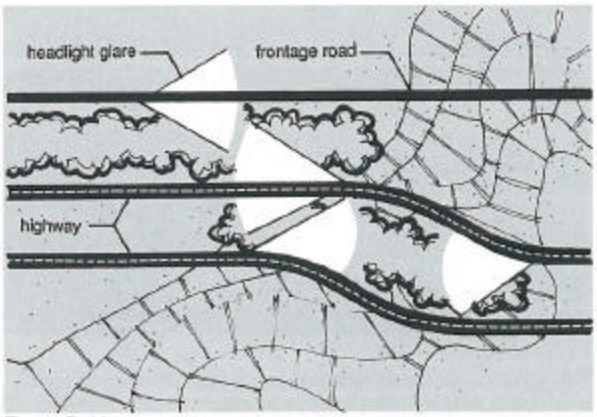

Figure D-40
For divided highways avoid convergent alignments where headlights will shine into the path of oncoming traffic.

Figure D-41
In this photograph, vegetation within the median minimizes the impact of headlight glare from oncoming traffic.

Figure D-42
A raised berm between opposing directions of traffic will also limit the impact of headlight glare.

6.0 Response to Views

Evaluate existing and potential views from the road to its surroundings and to the road itself.

.1 Consider that the "Area of Effective Vision" will have a significant impact on the driver's awareness of the roadside context.

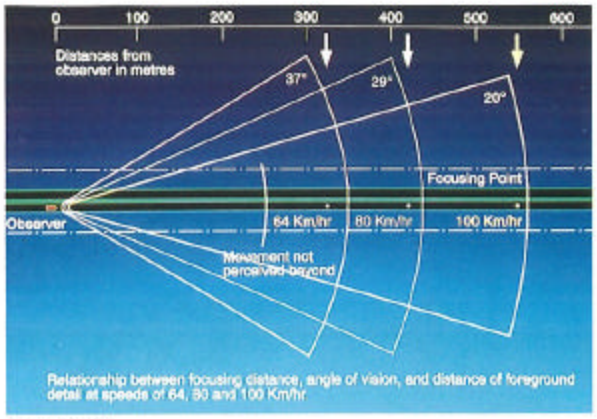

Figure D-43
The 'Area of Effective Vision' is expressed diagrammatically indicating a diminishing visual impact with increasing distance and greater angles away from the direction of travel.

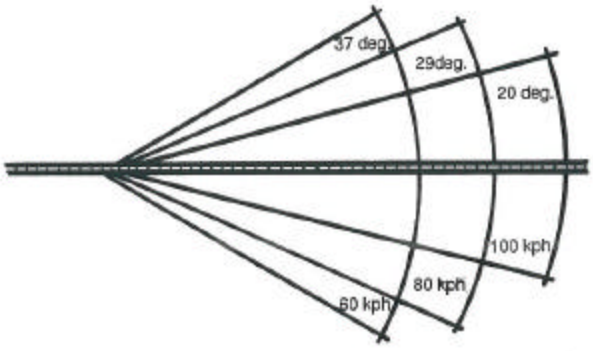

Figure D-44
The area of effective vision will become longer and more directional with increased design speeds.

.2 Minimize the view to utility corridors .

- Screen underground energy utility corridors from the road.*

*refer to CLEARING AND GRUBBING for integration with existing vegetation

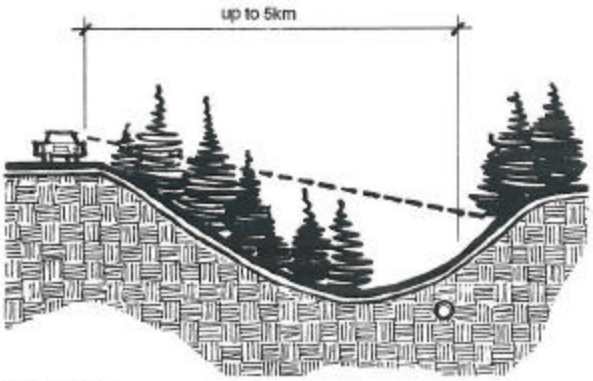

Figure D-45
When viewed from distances up to 5 km., where utility corridors cut through forest, screen the groundplane of the cleared right of way with vegetation and earthworks.

Figure D-46
Make revegetation of the utility corridor where it intersects the road a priority.

.3 Minimize the visual impact of high voltage powerlines.*

**refer to CLEARING AND GRUBBING for feathering and revegetation techniques*

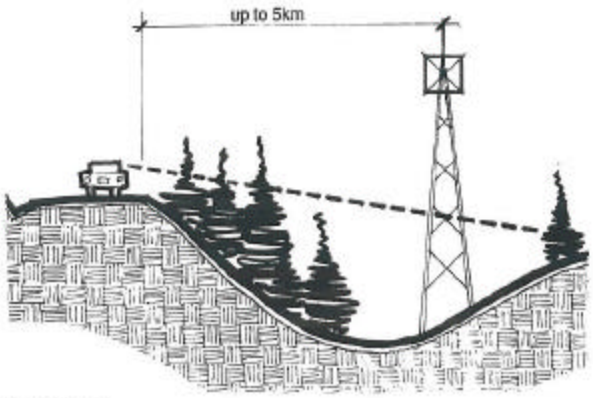

Figure D-47
Viewed from a distance of up to 5 km., where corridors cut through forests, screen the groundplane of the cleared right of way.

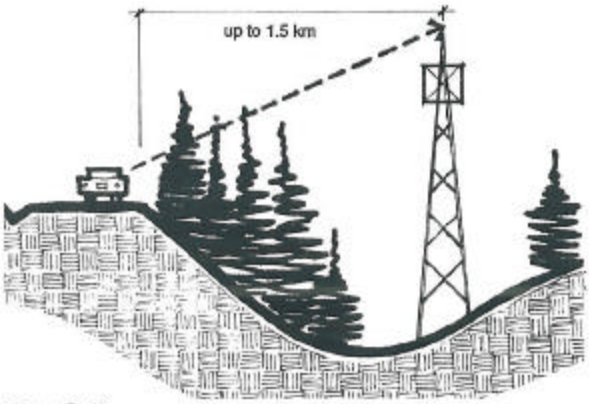

Figure D-48
In treed areas, viewed from distances up to 1.5 km., screen the powerline support structure.

Figure D-49
Do not align the road to focus on a powerline corridor at the end of a tangent.

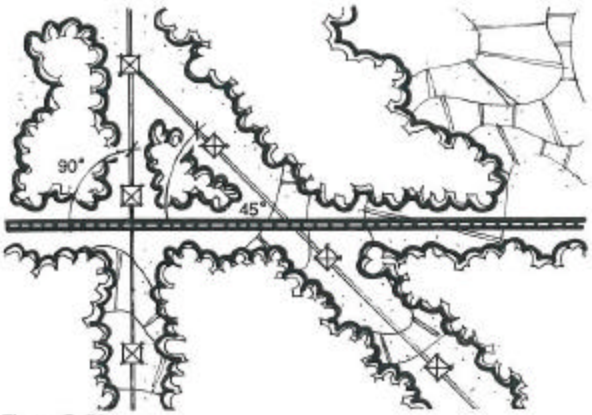

Figure D-50
Intersect the powerline with the road at the perpendicular or at an angle no less than 30 degrees.

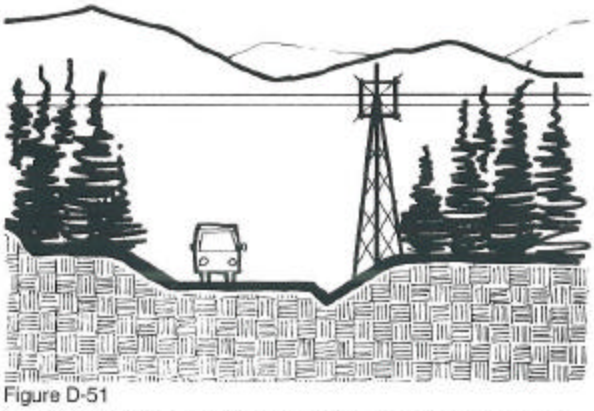

Figure D-51
In hilly or mountainous terrain, route the highway so that, from a distance of 0-1.5 km., the powerline, where it intersects the road, will not appear above the horizon line (eg. descending into a local low point with middleground backdrop).

.4 Minimize the impact of existing timber cuts and anticipate future timber cuts.*

- Develop alignments which reduce the negative visual impact in areas where existing timber cuts cannot be completely concealed.
- Provide a visual screen where clearcuts can be seen from the highway.
- Where future cutting is anticipated the visual integrity of the roadway should be protected through provision of buffers within the right of way, or by land use control, or by scenic easement controls in cooperation with the Ministry of Forestry.

**refer to EARTHWORKS and CLEARING AND GRUBBING for integration with adjacent site conditions*

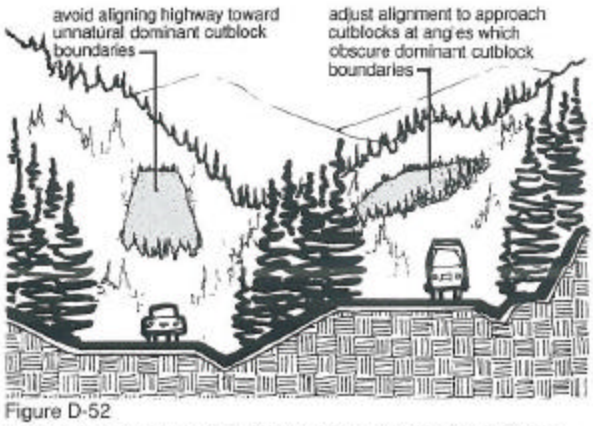

Figure D-52
Where cut has occurred within 3 years and when viewed from a distance of 5-8 km, avoid alignments which focus the road on dominant lines of the cut.

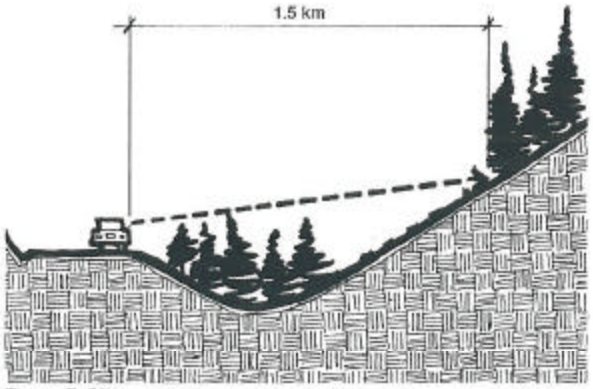

Figure D-53
When viewed from within 1.5 km., screen the area of the cut in its entirety.

Figure D-54
Additional space is required to construct an adequate visual screen which could have concealed this timber cut.

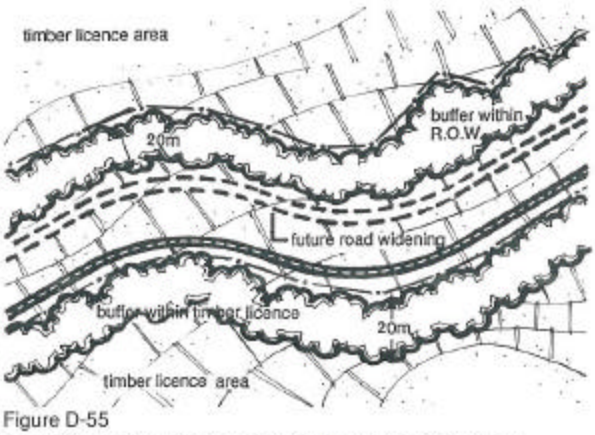

Figure D-55
Set aside a 20 m wide visual screen within the right of way, exclusive of future road widening and clearing requirements, OR require a 20 m wide perpetually forested screen within the adjacent allocated timber license area.

.5 Minimize views to unsightly uses such as garbage dumps, junkyards, manufacturing, and industrial or commercial parking areas and yard operations.

- Align tangent of road away from unsightly commercial uses, so that such uses are not evident within the area of effective vision.
- Provide pleasant views away from direction of unsightly use to divert driver's attention.*
- Avoid or screen view of ground plane of unsightly commercial business operations viewed from a distance of within 1.5km.**

**refer to VISUAL RESOURCE ANALYSIS and CLEARING AND GRUBBING and VEGETATION MANAGEMENT for identification of potential views and integration with adjacent site conditions*

***refer to EARTHWORKS and VEGETATION MANAGEMENT for integration to adjacent site conditions*

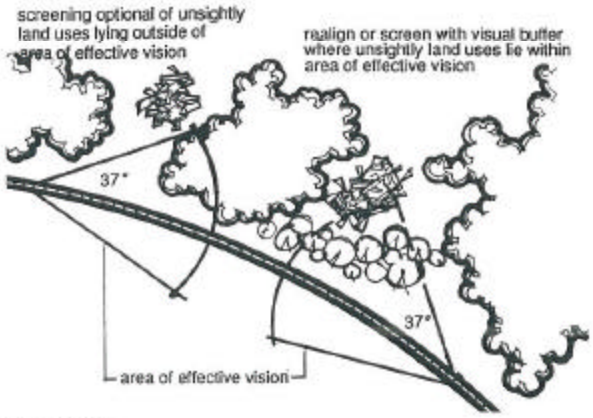

Figure D-56
Align tangents away from those commercial uses which are unsightly. For business operations immediately adjacent to the road, provide room for a minimum 20 m wide vegetative buffer. Buffer may take the form of an earthwork berm if appropriate to local terrain.

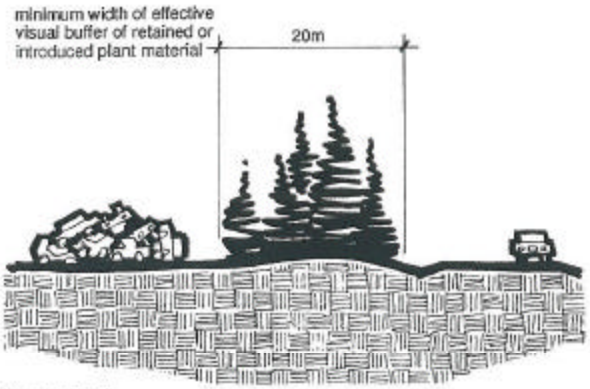

Figure D-57
Buffers of native vegetation should be minimum 20m width in rural areas.

Figure D-58
Alignment does not allow sufficient room to screen these commercial billboards on private property. More signs are being erected in cleared areas to the right of the photograph. There is not sufficient right-of-way to establish a buffer zone.

.6 Recognize and enhance potential views.

- Adjust alignment to gain view.
- Align road so that view can be accommodated from roadside facility.*
- Provide alignment which will expose views in manner appropriate to a moving vehicle.
- Adjust alignment to provide a variety of views, avoiding the monotony of a constant 'good' view.**

Figure D-59
Some planting has been undertaken to screen this hydro installation. A more continuous planted buffer would have been more successful.

Figure D-60
Where highways are aligned on upper slopes recognize the opportunity to create spectacular viewpoints.

Figure D-61
Skirt open spaces which provide views (eg. agricultural or forest clearings or open spaces associated with water such as rivers, streams, oceans, lakes, reservoirs, marshes, bogs).

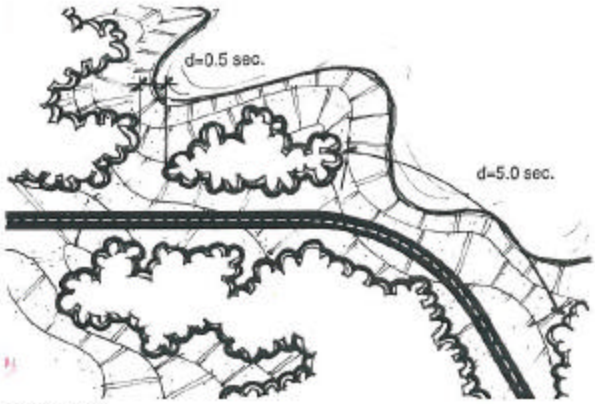

Figure D-62
Expose views for a minimum of 0.5 seconds for fleeting views, 5.0 seconds for panoramic views.

refer to ROADSIDE FACILITIES for space, and accessibility requirements

refer to VISUAL RESOURCE ANALYSIS for identification of potential views

**refer to CLEARING AND GRUBBING and REVEGETATION for integration with adjacent vegetative conditions*

**refer to ROADSIDE FIXTURES and ABOVE GROUND UTILITIES to ensure enhancement of views*

**refer to VISUAL RESOURCE ANALYSIS for analysis of potential views*

7.0 Response to Vegetation

Retain existing vegetation to mitigate an alignment's impact and therefore enhance the driver's experience.

.1 Respect existing natural vegetation patterns.

- Align road along natural plant community edges.
- Align road at edge of natural clearings of forests.*
- Road alignments through homogeneous plant communities will require special attention to keep drivers alert and attentive.**

Figure D-63
Retain natural elements which provide a break from the view for a minimum of 0.5 seconds, at irregular intervals (5 minutes apart).

Figure D-64
Align road along forest edges. Forested conditions require alignment to respond to changes in vegetation type and density.

.2 Respect existing man-made vegetative patterns

- Align roads parallel with shelterbelts, hedges.
- Align tangents toward landmark trees.

**refer to CLEARING AND GRUBBING, and REVEGETATION for creating natural forest edges*

***refer to EARTHWORKS, CLEARING AND GRUBBING and VEGETATION MANAGEMENT for integration with adjacent site conditions*

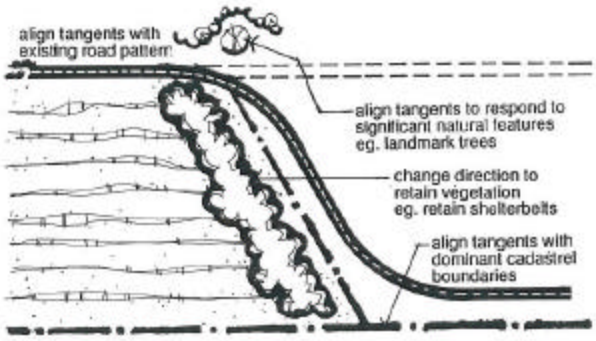

Figure D-65
Align roads parallel to hedgerows and make tangents focus on significant landmark trees.

Figure D-66
This maple retained within the median contributes to the overall quality of the highway and to the driver's experience.

8.0 Secondary Aesthetic Impacts - Climate

Actions undertaken to mitigate the impact of adverse climatic conditions should consider potential aesthetic consequences.

.1 Align road to minimize potential icing conditions in high risk areas.

.2 Align road to minimize effects in high risk snowdrift conditions.

- Set alignment back a distance of 7 to 8 times the height of a moderate (50%) vegetative screen (preferred).
- Set alignment back a distance of 11 to 12 times the height of a light (25%) vegetative screen.
- Set alignment back a distance of 13 to 14 times the height of a dense (75%) vegetative screen.

.3 Minimize the occurrence of sun glare.

- Avoid alignments running directly east or west into a rising or setting sun.
- Feather vegetative edges to reduce abrupt transitions from full shade to full sun.

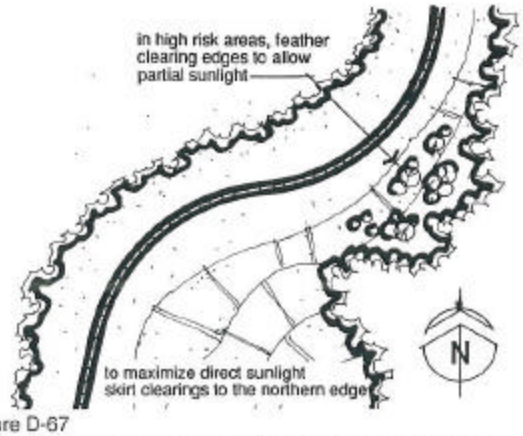

Figure D-67
Expose road surface to direct sunlight from east and south directions by alignments skirting clearings, providing for feathering of vegetation on south and east, and decreasing amount of cut zones.

Figure D-68
Where aesthetics warrant vegetation close to the pavement, review early morning sun angles to minimize icing. Adjust alignment and/or vegetation to reduce problems as identified.

9.0 Secondary Aesthetic Impacts - Ecosystems

Consider potential aesthetic responses to negative ecological impacts attributed to road alignment.

.1 Consider the implications of changes to waterflow patterns.

- Avoid obstruction of drainage patterns with fill.*
- Anticipate channelling and avoid subsequent erosion.**

Figure D-69
In this photograph an ecologically well resolved culvert outflow needs additional care to create an aesthetically satisfactory solution.

.2 Consider the implication of grade changes to the continuity of wildlife habitat.

Figure D-70
Roadway alignment should recognize and skirt sensitive habitat areas.

**refer to VISUAL RESOURCE ANALYSIS for identification of potential alignment constraints*

**refer to EARTHWORKS, CLEARING AND GRUBBING and REVEGETATION for integration with adjacent site conditions*

**refer to ROADWAY STRUCTURES (Retaining Walls) for consideration of walls in lieu of earthworks*

***refer to ROADWAY STRUCTURES (Bridges and Overpasses) for consideration of alternatives to fill*

10.0 Secondary Aesthetic Impacts - Adjacent Land Use

Consider responses to aesthetic impacts directly attributed to land use changes caused by road alignment.

.1 Avoid unproductive divisions of land that encourage abandonment or leases to uses deemed unsightly (eg. billboards).

- Align to property boundaries.
- Incorporate unproductive units of land into right-of-way.
- Provide access to isolated sections of land. Such access might be separate from the controlled access highway if necessary.

.2 Minimize impact of temporary facilities related to road construction.

- Site borrow pits within median or right of way wherever feasible.
- Where not feasible to keep temporary facilities (eg. borrow pits) within alignment, allow for a retained or future vegetative screen of 20m width and/or rehabilitative earthwork of a height necessary to screen the groundplane of the site.
- Intersect access road with the primary road right-of-way at a 90 degree angle. The tangent of the access road at the intersection should be no longer than 15m with the curve leading into this tangent of no less than 15 degrees.
- Where locations permit, quarries and construction camp sites should be chosen for potential development as roadside facilities.

**refer to EARTHWORKS and VEGETATION MANAGEMENT for integration with adjacent site conditions*

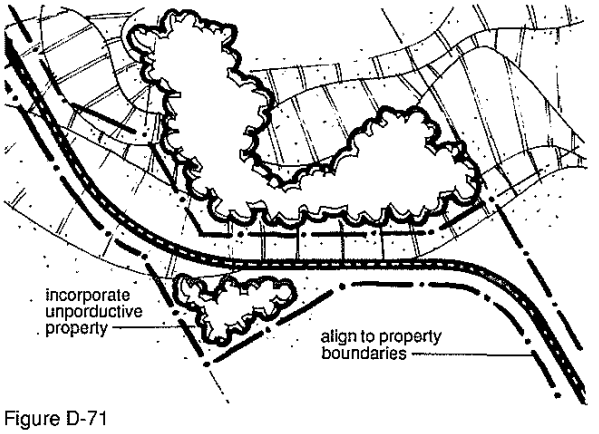

Figure D-71
Alignment should follow property boundaries where possible. Small, isolated parcels should be purchased for right of way.

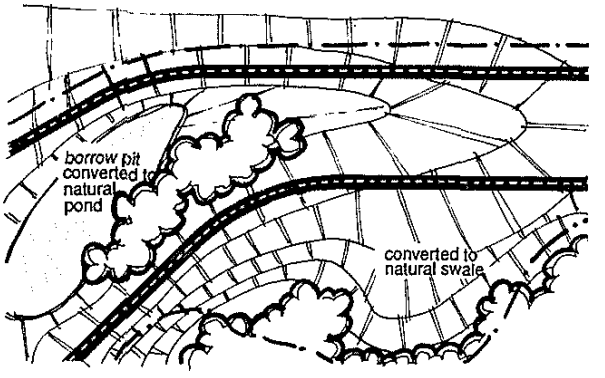

Figure D-72
Borrow pits can be integrated into earthwork design within the right of way.