GEOptics Landscape Apparency

a dynamic visual resource indicator
for multi-functional landscape planning

Presentation to the Examining Committee
by

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Agenda

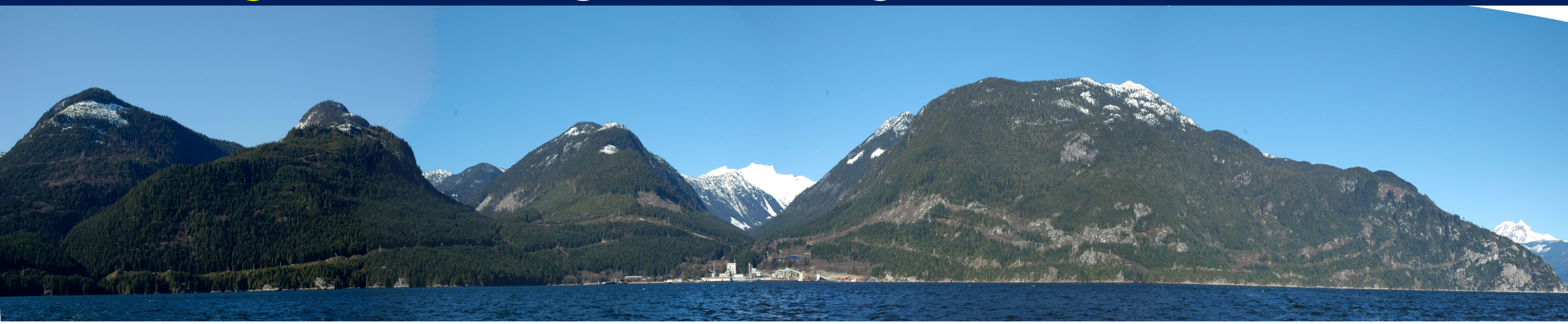
1. **Issues / Problems**
2. **Research Question**
3. **Possible Solution**
4. **Research Tasks**
5. **Evaluation Criteria**
6. **Current Landscape Processes**
7. **Concepts Related to Apparency**
8. **Building an Apparency Model**
9. **Tests and Trials / Results**
   1. **Internal**
   2. **External Focus Groups**
10. **Discussion and Conclusions**

Issues

- The visual landscape is a public good
- Visual impacts affect public opinion of forestry
- Poor design has enduring effect on next passes

Problems

- Coarse inventory delineation and categorization
- VQO's may be overly or inadequately constraining
- Forest operations "can't find the wood"
- Visual design in only 42% of harvested openings
- Design skills lacking or not being utilized



2. Overall Research Question

Could a new approach improve the worth* of one or more key components of an expert visual assessment system, i.e., the BCMOFR Visual Landscape Management System:

- **Visual Resource Allocation and Protection**
- **Integrated Resource Planning**
- **Visual Landscape Design**

***** *"Expert visual assessment systems must be assessed for their worth in a variety of measures – sensitivity, reliability, validity and utility….unless an assessment method is sensitive and reliable, it can not achieve an acceptable level of validity"*** **(Daniel and Vining '83).**

3. Possible Solution

GEOptics Landscape Apparency:

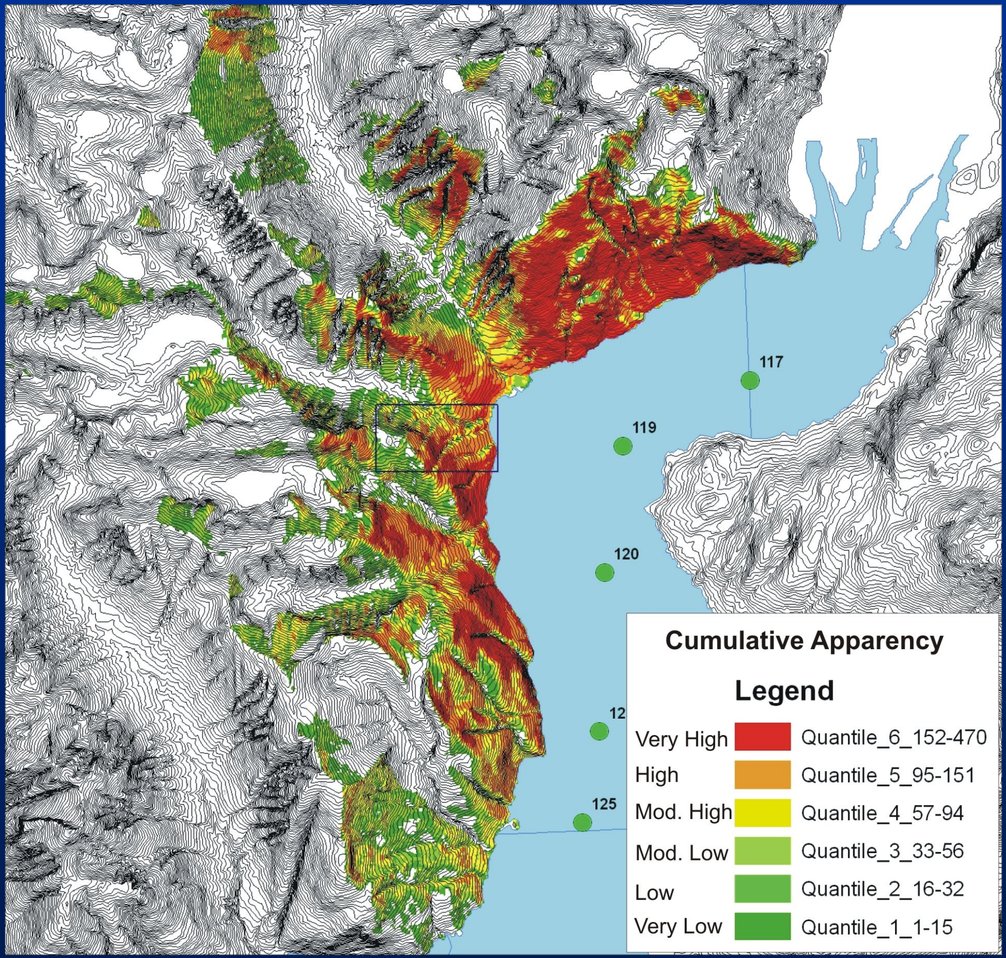
A quantified visual risk indicator and tool…

capturing the dynamic interaction…

between the viewer and the landscape…

as determined from an array of viewpoints…

within a digital 3-D terrain environment.



Cumulative Apparency Map Example

4. Research Tasks

1. Examine **expert visual assessment** (EVA)

2. **Develop** a refined vulnerability/risk assessment tool and evaluation criteria

3. Conduct internal **pre-testing**

4. Evaluate by **internal** tests

5. Evaluate by **external** tests (focus groups)

6. **Findings**, conclusions, further research and applications

5. Evaluation Criteria

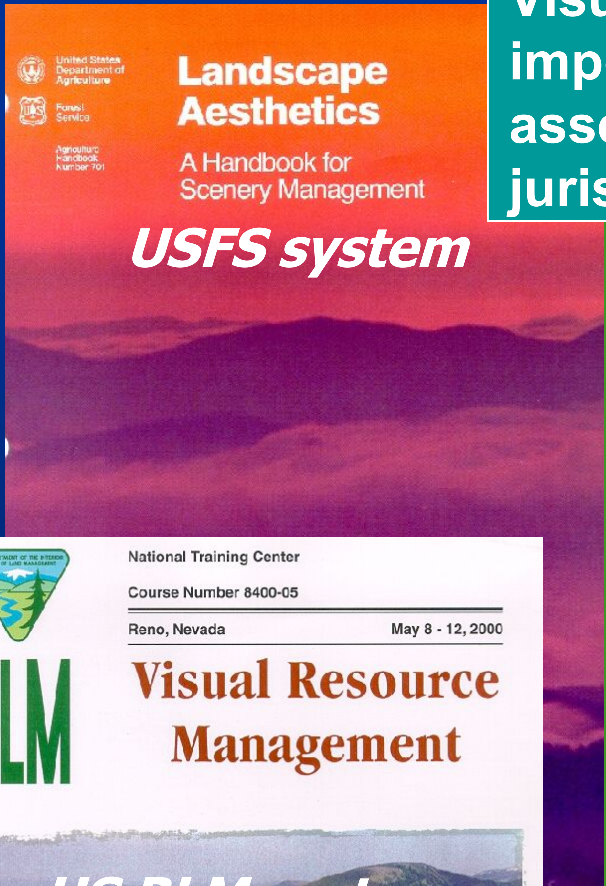
"Improving the worth of one or more key components of an EVA"

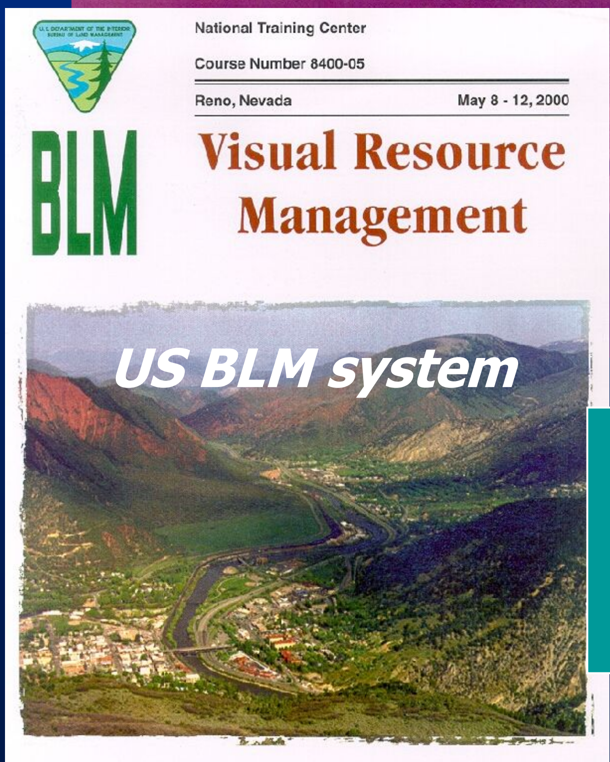
- Internally:
  - Reliability – agreement or consistency (precision/accuracy)
  - Sensitivity – method is sensitive to changes
  - Validity – measures what the system purports to measure
  - Utility – efficiency and generality

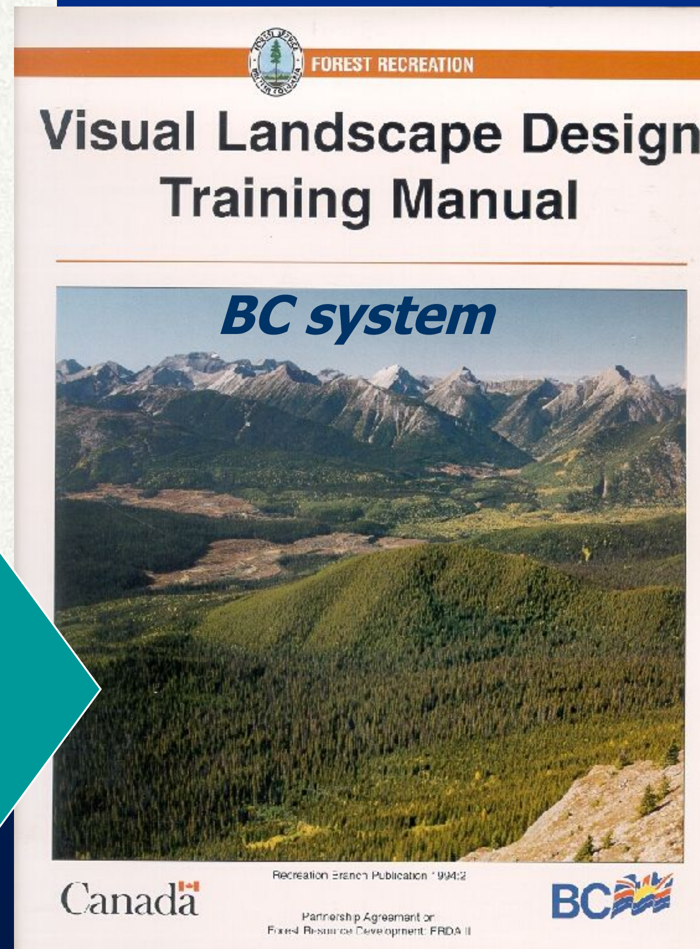
- Externally:
  - Advancement – inventory, planning and design
  - Utility – familiar programs, quick, easy, interest to do so
  - Adaptability – programs, systems
  - Compatibility – existing systems - ArcGIS
  - Generality – jurisdictions, applications

6. Current Landscape Processes

Visual risk assessment and planning procedures are important components of major expert visual assessment processes in British Columbia and other jurisdictions:

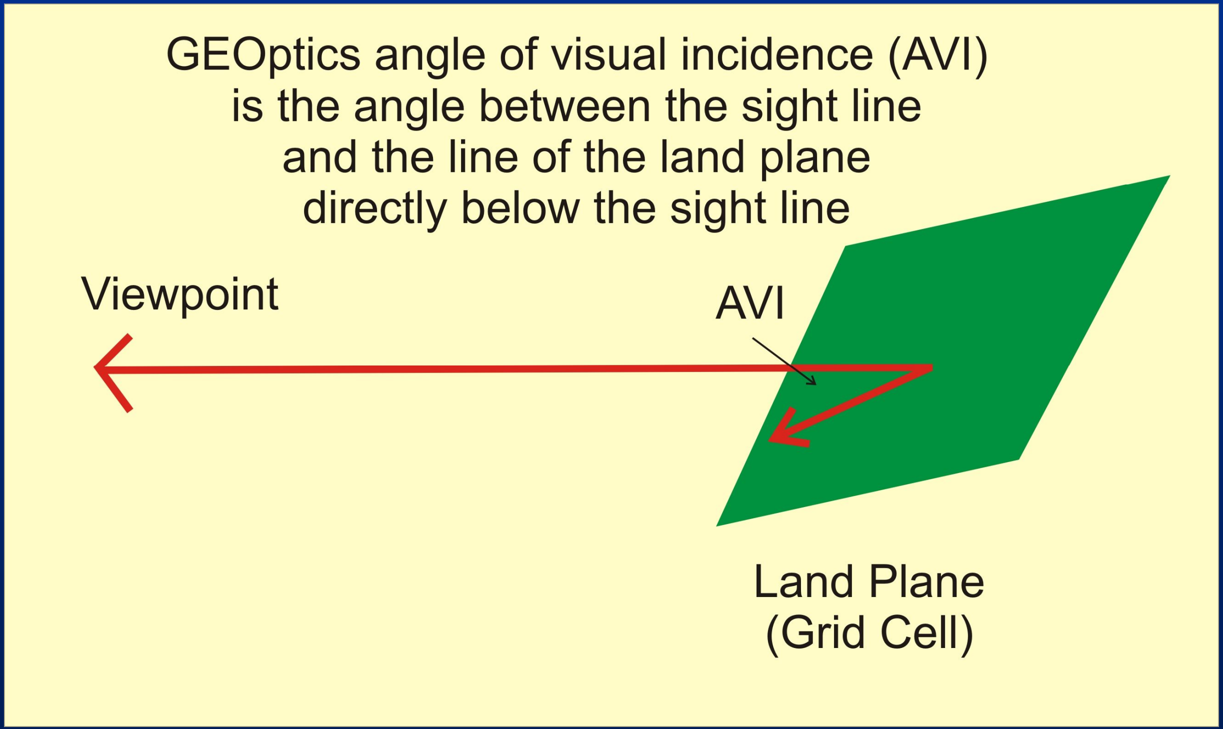






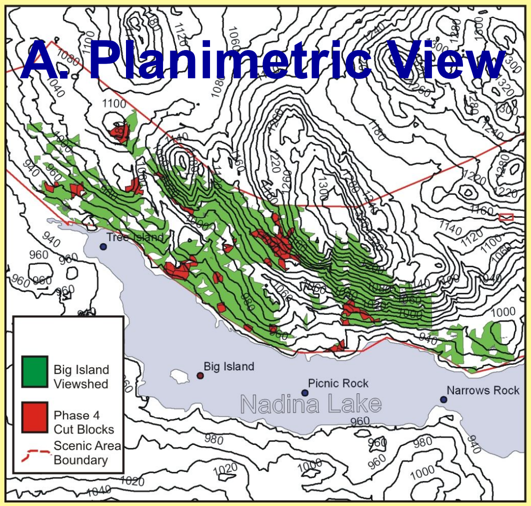
7. Concepts Related to Apparency

- Visual Contrast
- Visual Vulnerability
- Visual Absorption
- Visual Magnitude
- Visual Threshold
- Viewed Land Plane
- Visual Incidence
- Plan-to-Perspective Ratio



Plan-to-Perspective (P2P) Ratio

B) Nadina Lake - Big Island Perspective Viewshed
Phase 4 Cut Blocks outlined in yellow - 3% alteration



A) Nadina Lake Big Island Viewshed Plan View
Phase 4 Cut Blocks in Red
15% Planimetric Percent Alteration

Percent Alteration Calculation

A) Plan View: 15%

Big Island viewshed plan area = 495.6 ha.
Big Island viewshed Phase 4 alteration = 73.8 ha
Planimetric percent alteration: 73.8/495.6 = 15%.

B) Perspective View: 3%

Big Island viewshed perspective area = 3,621,481 units^2
Phase 4 perspective alteration in viewshed = 118,195 units^2
Perspective percent alteration: 118195/3621481 = 3.3%.

C) Plan-to-Perspective Ratio: 5:1

Big Island Viewshed plan to perspective area = 495.6 ha.
Big Island Viewshed Phase 4 alteration
Plan-to-Perspective Ratio = 15%/3% = 5:1

(Numbers rounded for demonstration purposes)

P2P ratio = A/B (in percent)

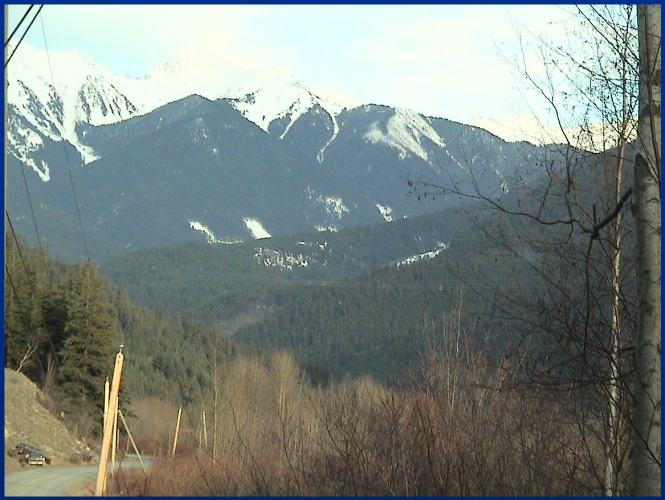
Predicted P2P ratios for slopes 0% - 70% for all visual designs (BCMoF 2003).

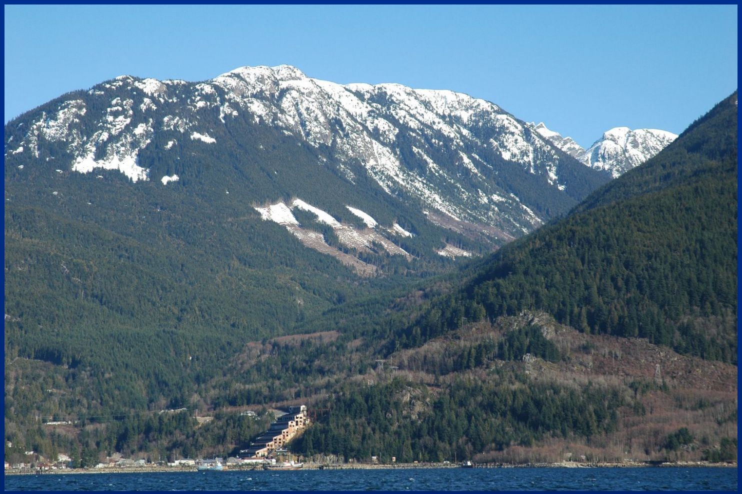
Slope	0%	10%	20%	30%	40%	50%	60%	70%+
P2P	4.68	3.77	3.04	2.45	1.98	1.60	1.29	1.04

The results subsequently were used to adjust the P2Ps used in timber supply review (BCMoF 2003). The standard is 2:1.

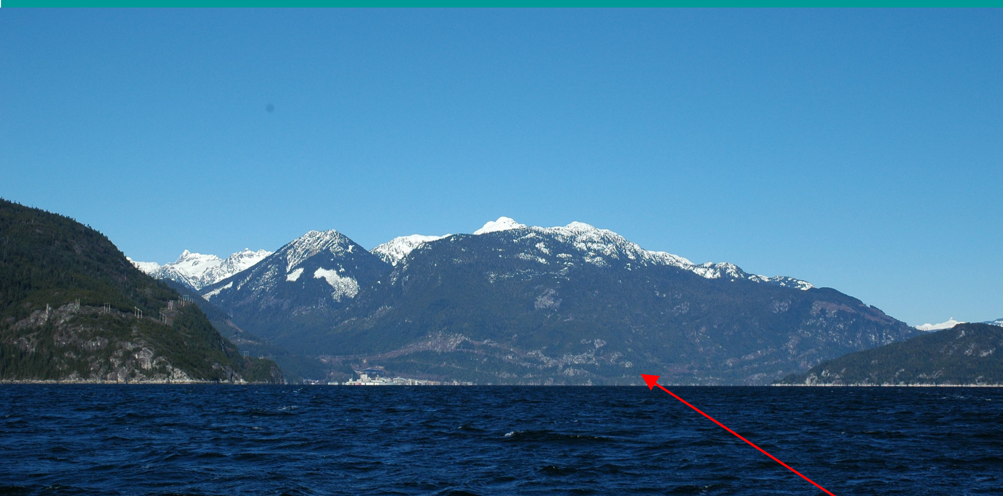
The findings indicated P2P could rise to as high as 14:1 for good design at 0% slope.

Visual Absorption Capability (VAC)



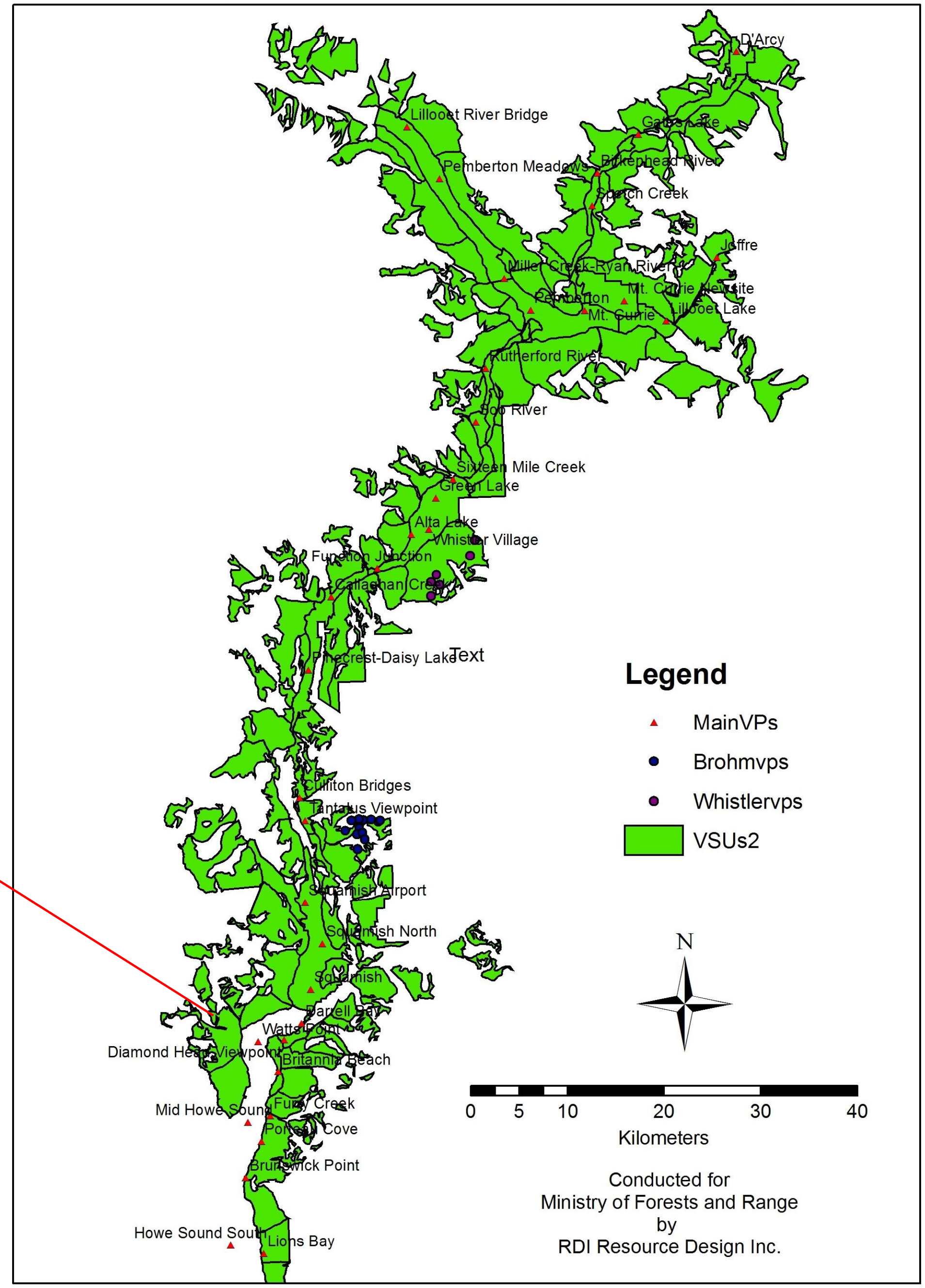


VAC is the ability of a particular landscape unit to accept visual alteration or resist visual impacts, the opposite of visual vulnerability



VAC is determined during BCMOFR's visual landscape inventory process, applied to **large** Visual Sensitivity Units as a 3-class rating: (High-Moderate-Low).

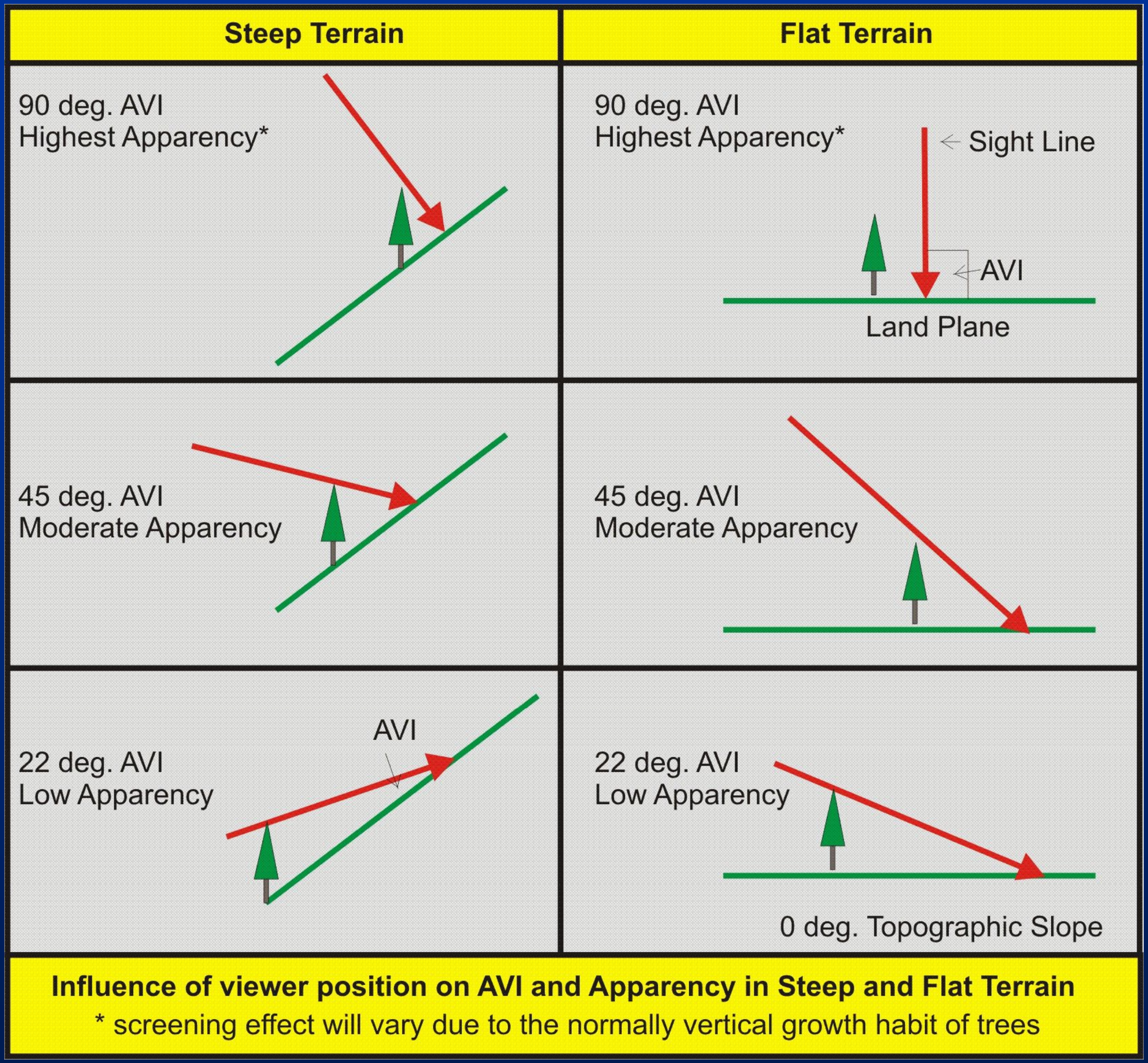
Sea-To-Sky Visual Landscape Inventory 2006



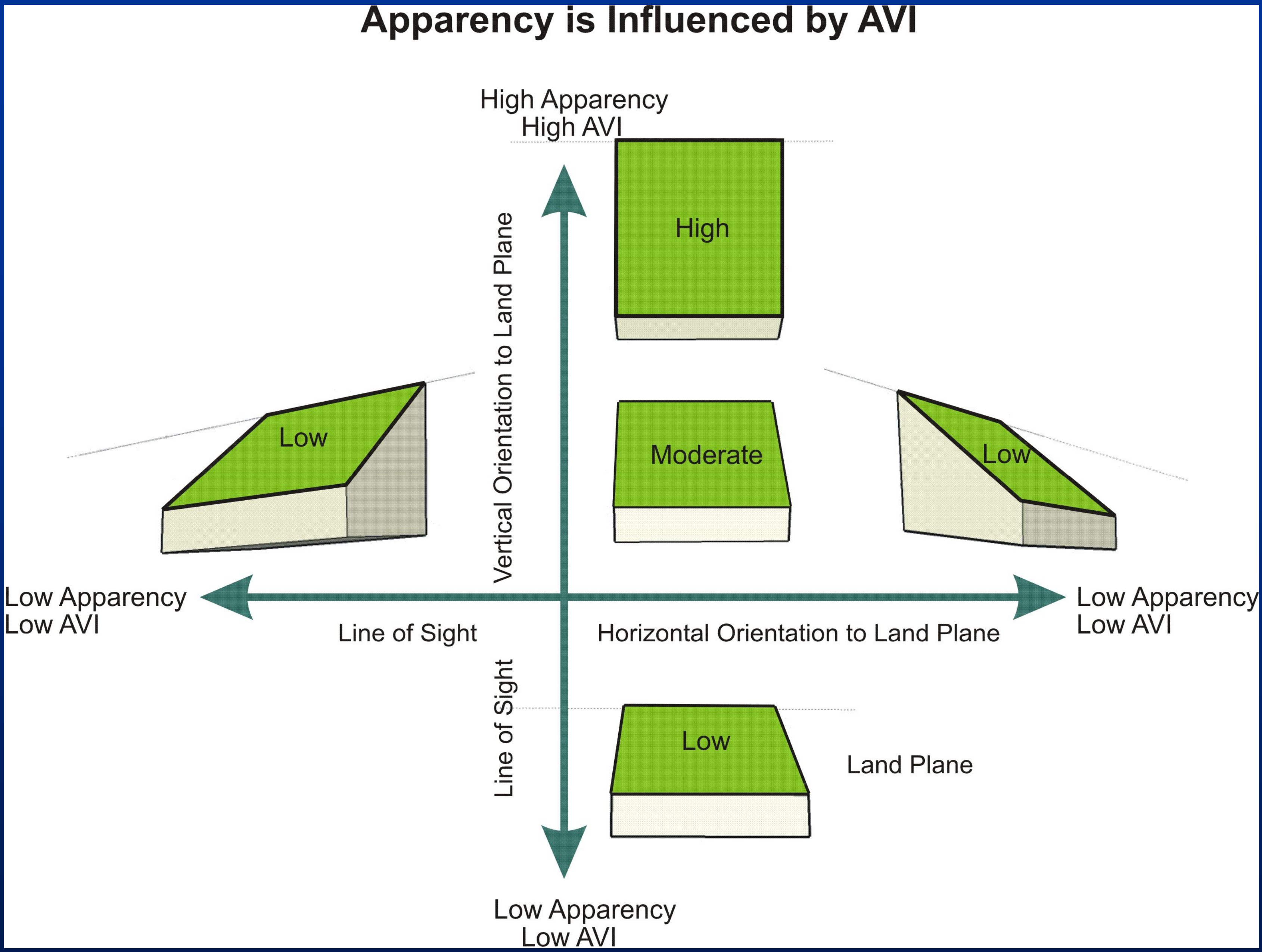
Multiple/Moving Viewpoints – Changing Perspectives



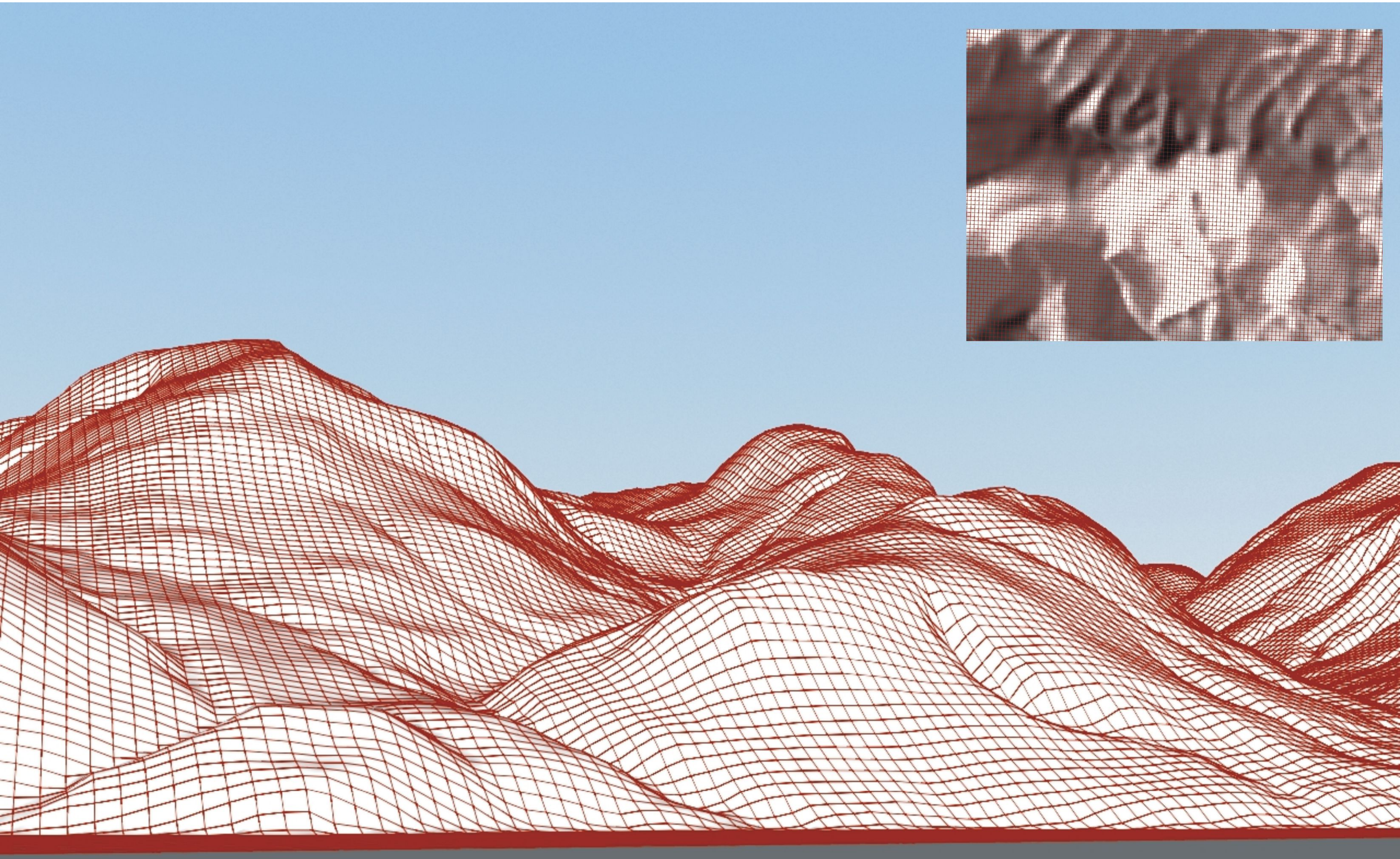

Pryce Channel - Left to Right Views



Viewer Position Affects AVI and Apparency in Steep and Flat Terrain.



Angle of Visual Incidence (AVI) is *the angle between the sight line and the land plane at the point of incidence*.

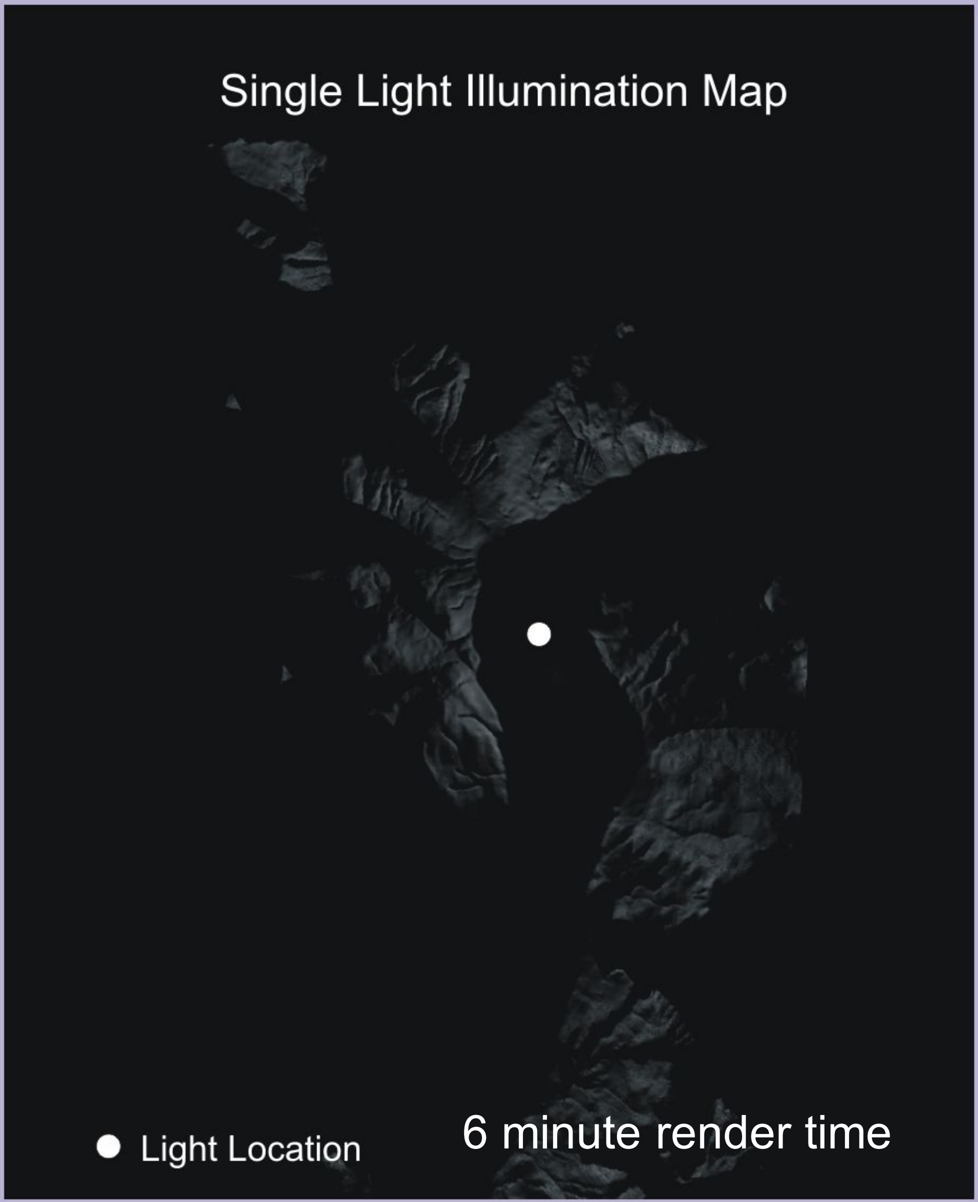


Angle of visual incidence and apparency affect the scale and shape of individual land planes relative to the viewpoint. Inset shows the planimetric pattern of 25 metre grid cells.

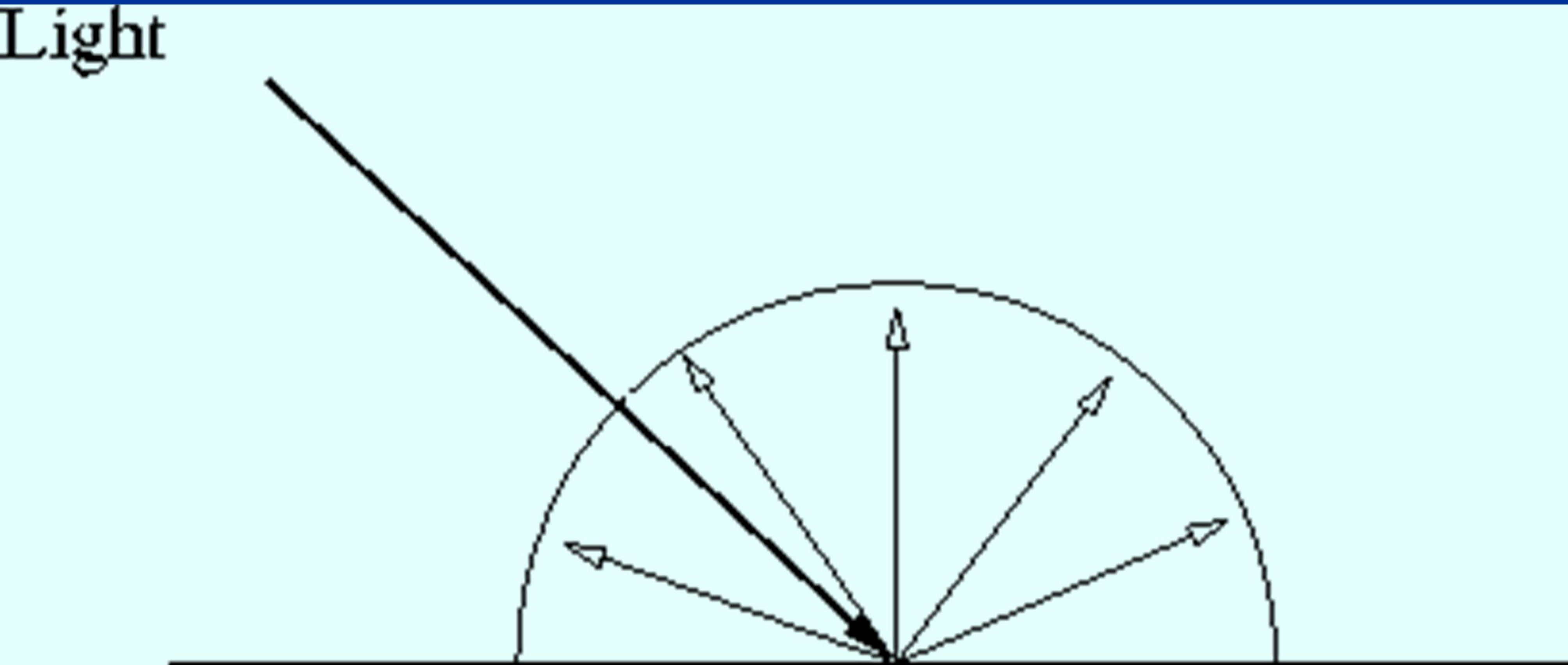
8. Building an Apparency Model:

- ArcGIS and Visual Nature Studio (VNS)
- Illumination analog of cumulative "viewing" intensity
- Visual representation of angle of incidence
- Models what is seen and how it is seen (light intensity)
- Model ready for 3-D perspective visualization; design
- Map Classification; Multiple Attribute Analyses in ArcGIS
- Integrated Planning
- Automation (FPS-Atlas)

Howe Sound VNS Model

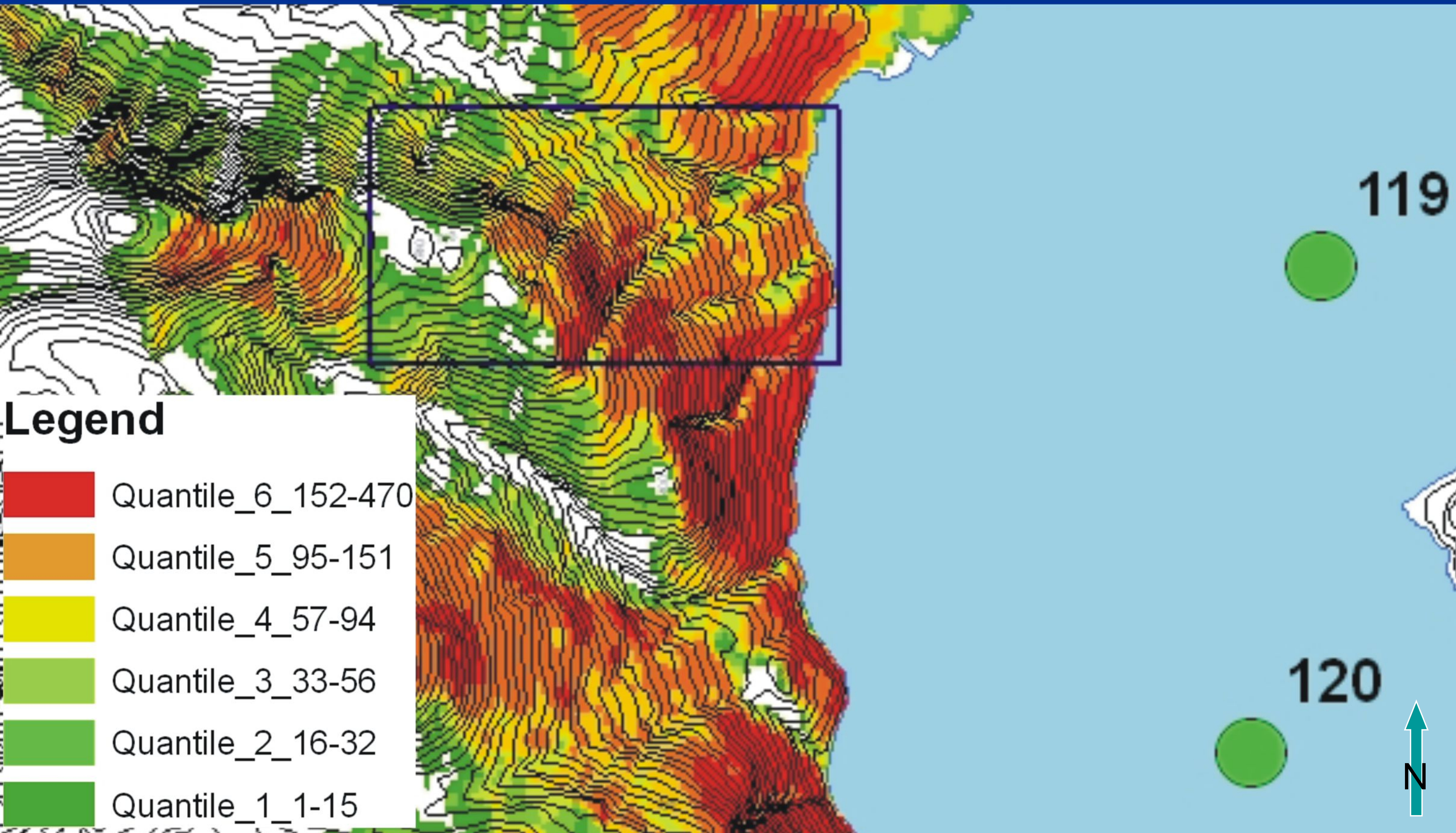


Apparency is determined from the intensity of illumination (reflected light) from each land plane in a digital terrain model. Render time varies with model size, lights, and number of shadow maps.



Light is reflected with equal intensity in all directions allowing measurement in planimetric (map) view

Five Viewpoint Cumulative Apparency Map Close-up



Scale Box 1km x 2km

9. Apparency Model
Internal Tests and Results

Landscape Apparency Internal Tests and Applications

Test Environmen t	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Internal Trials, Tests, and Applications Results	Terrain	Illumination	Classification	Integration	Applications A Strategic Planning	Applications B Tactical and Operational
	Terrain model construction Other GIS	Light Placement Intensity, Reflectance Illumination / Shadow Maps Single and Cumulative Illumination maps	Classify into “equal area” quantiles Single light, cumulative lights Comparison with viewshed, times-seen, and slope mapping	GEOTIFFs to vector polygons Integration with other attributes	Percent alteration P2P tests	Integrated visual design Automated design (Atlas) Cutblock location Multiple attribute application
Projects	Howe Sound project; Nadina IVDP.	Pre-tests: Stella Lake; Dishtin.	Howe Sound project; Nadina IVDP.	Howe Sound; Nadina IVDP.	Howe Sound; Nadina.	Nadina IVDP; Atlas-Nadina; Howe Sound.

Apparency Results
Comparisons with Conventional Methods
(Highlights from Dissertation)

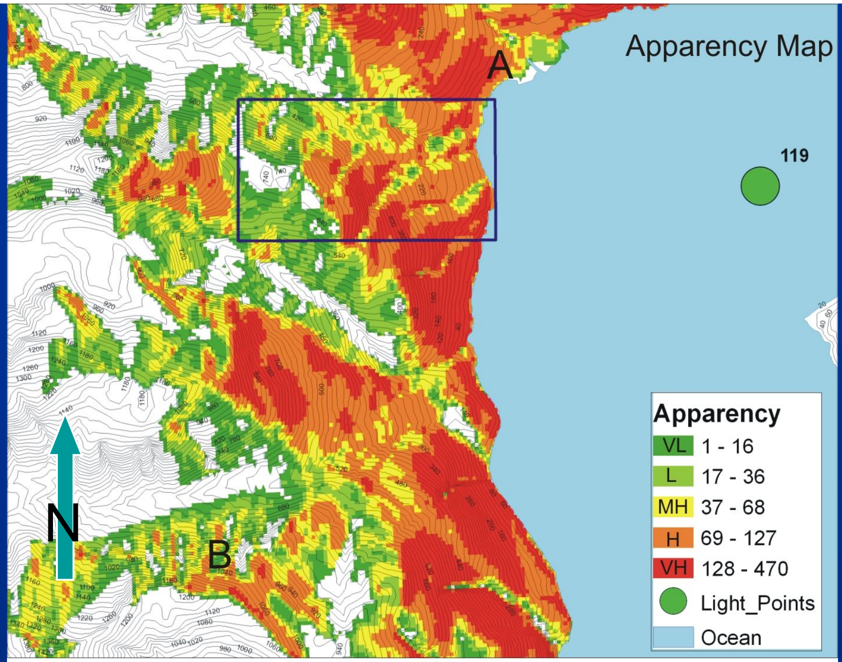
Test Area 1 – Howe Sound

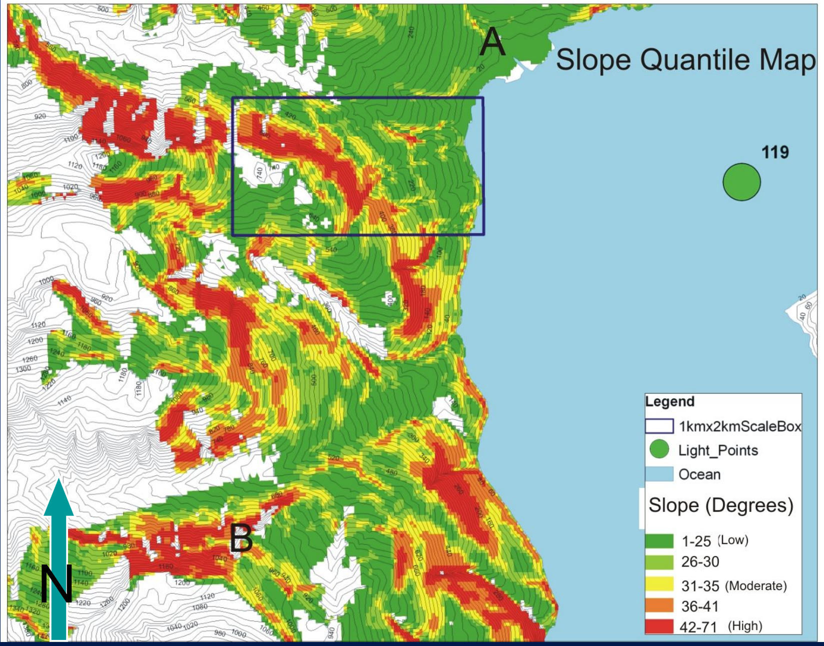
Slope is a coarsely-rated (3-class) BCMOFR VAC factor and a moderator of VQO percent alteration in Timber Supply

"a crude axiom may be suggested:

the steeper the slope, the greater the potential for visual vulnerability."

Litton '73





Apparency Map

5 equal area quantiles

Compare areas marked "A" in each and "B" in each

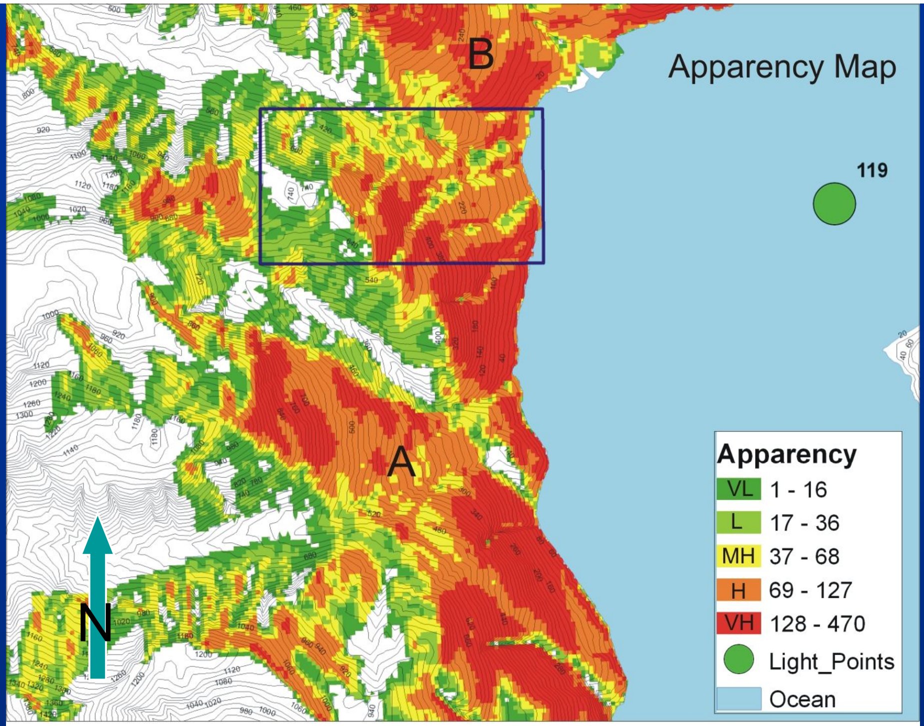
Slope Map

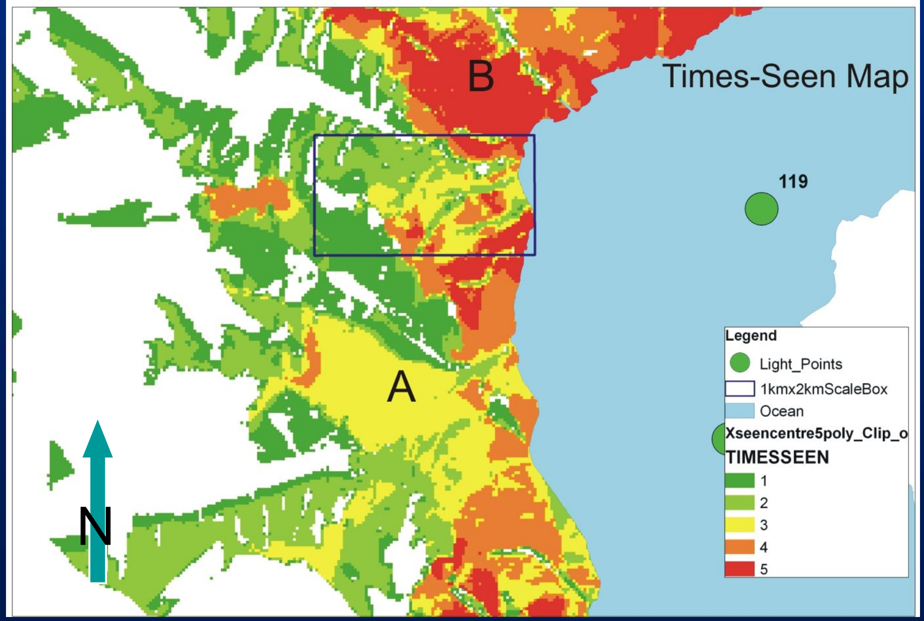
5 equal area quantiles

Comparison of cumulative apparency and topographic slope analysis

Times-seen is a conventional GIS measure emphasising areas of greater or lesser visibility by number of viewpoints observing a piece of land (visible or not visible only).

Not used in VLI.



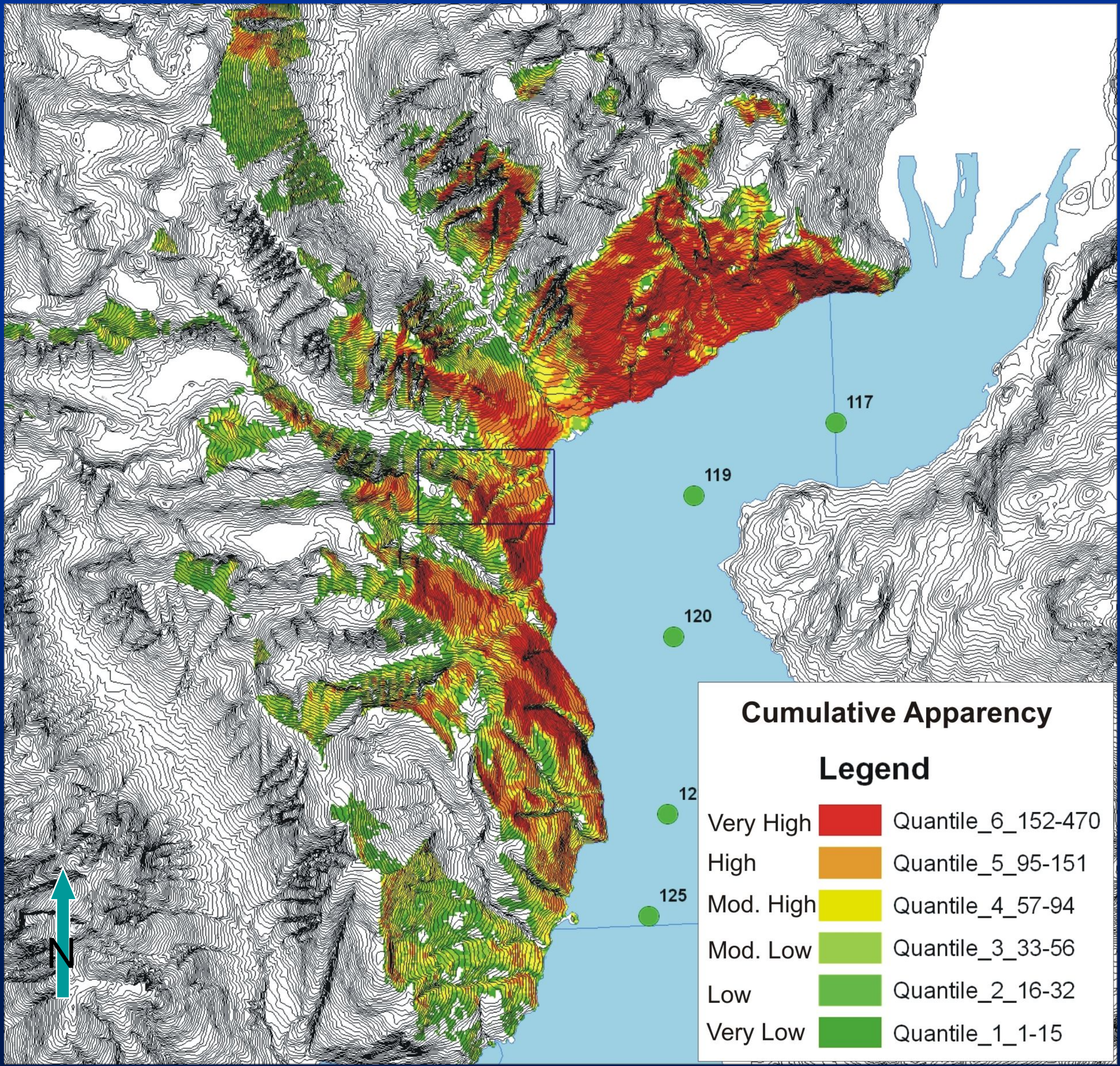


Apparency Map

Compare areas marked "A" in each and "B" in each

Times-seen Map (produced from 5 viewpoints)

Comparison of Howe Sound project cumulative apparency and times-seen



Cumulative apparency raster map with six classes of apparency Howe Sound west side model.

Howe Sound Apparency Quantile (equal area) Projections LCP117

(identifying visual risk and appearance if logged)

Quantile 1 – Very Low Risk (VL)

Quantile 2 – Low Risk (L)

Quantile 3 – Moderately Low Risk (ML)

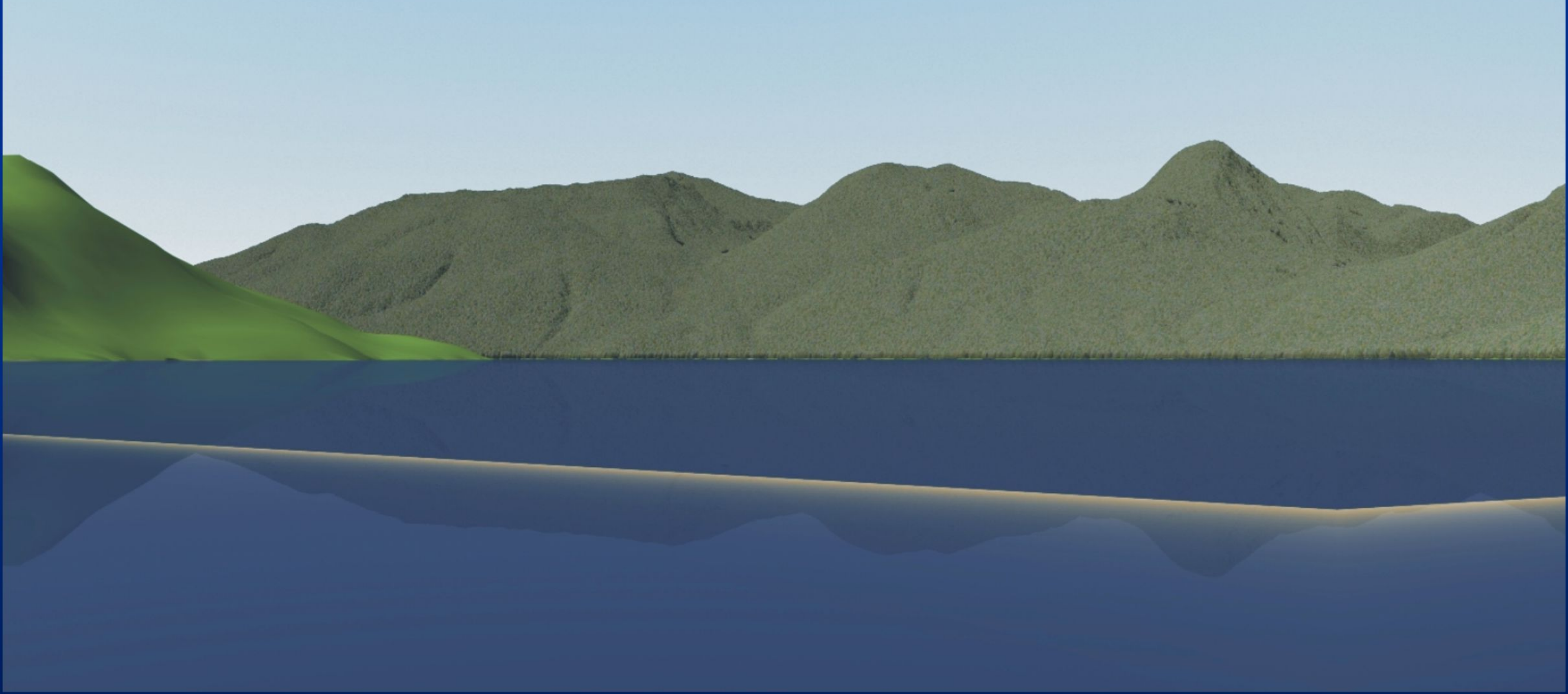
Quantile 4 – Moderately High Risk (MH)

Quantile 5 –High Risk (H)

Quantile 6 – Very High Risk (VH)

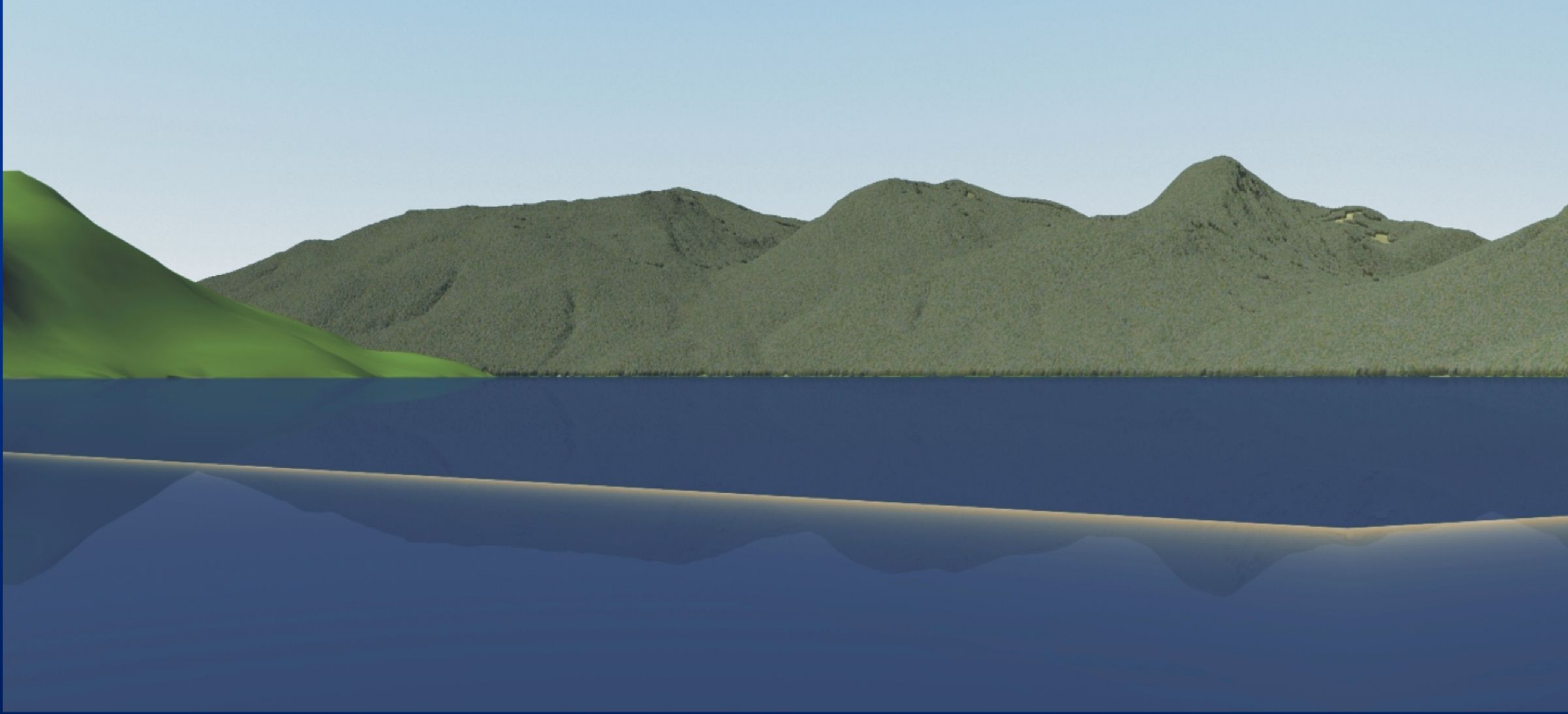
Default Forest Cover 25-30m Height

Howe Sound Apparency Quantile (equal area) Projections LCP117



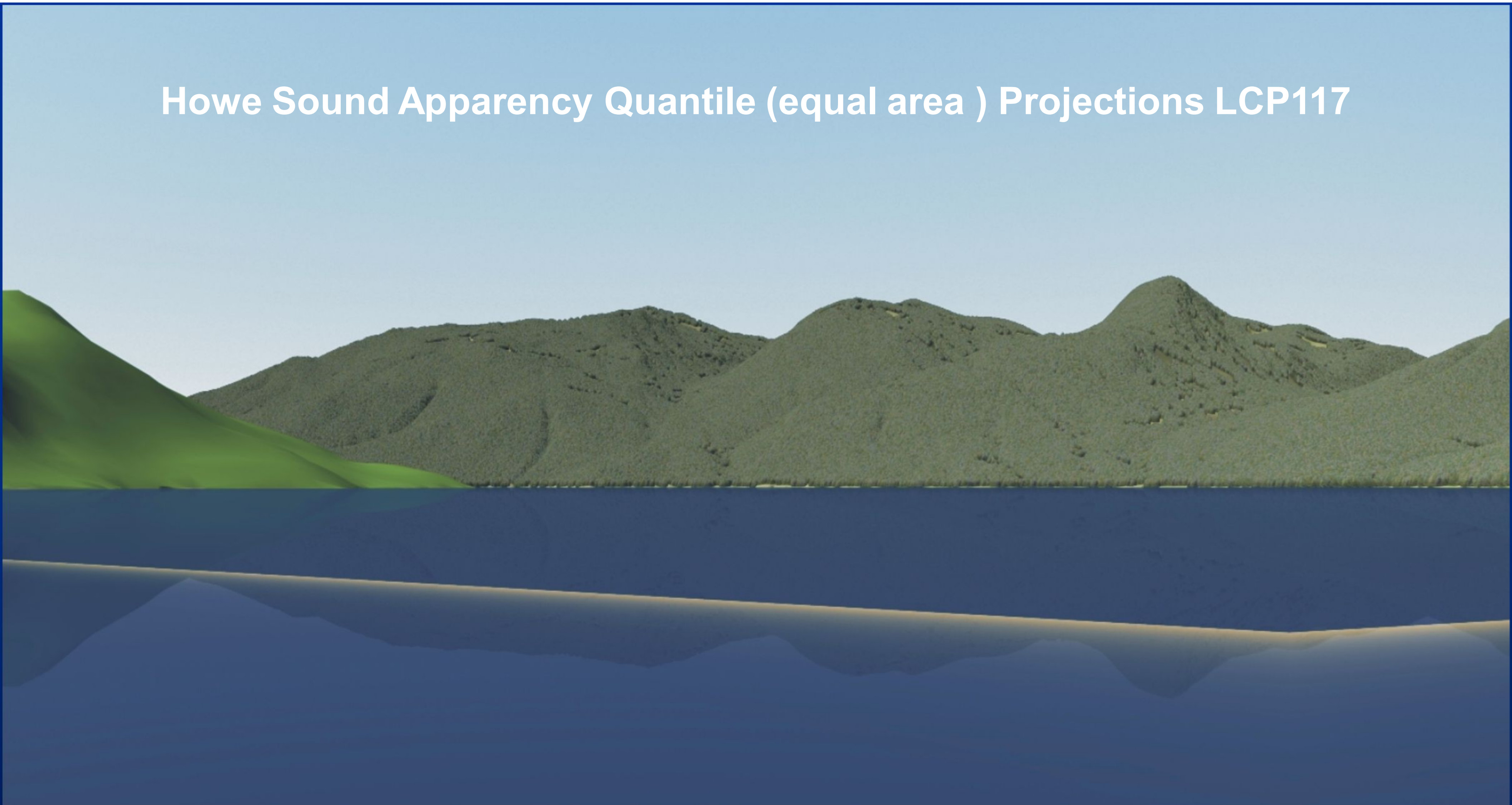
Quantile / Risk	Plan (%)	Pers. (%)	P2P
1 / VL	11	0.05	218:1

Howe Sound Apparency Quantile (equal area) Projections LCP117



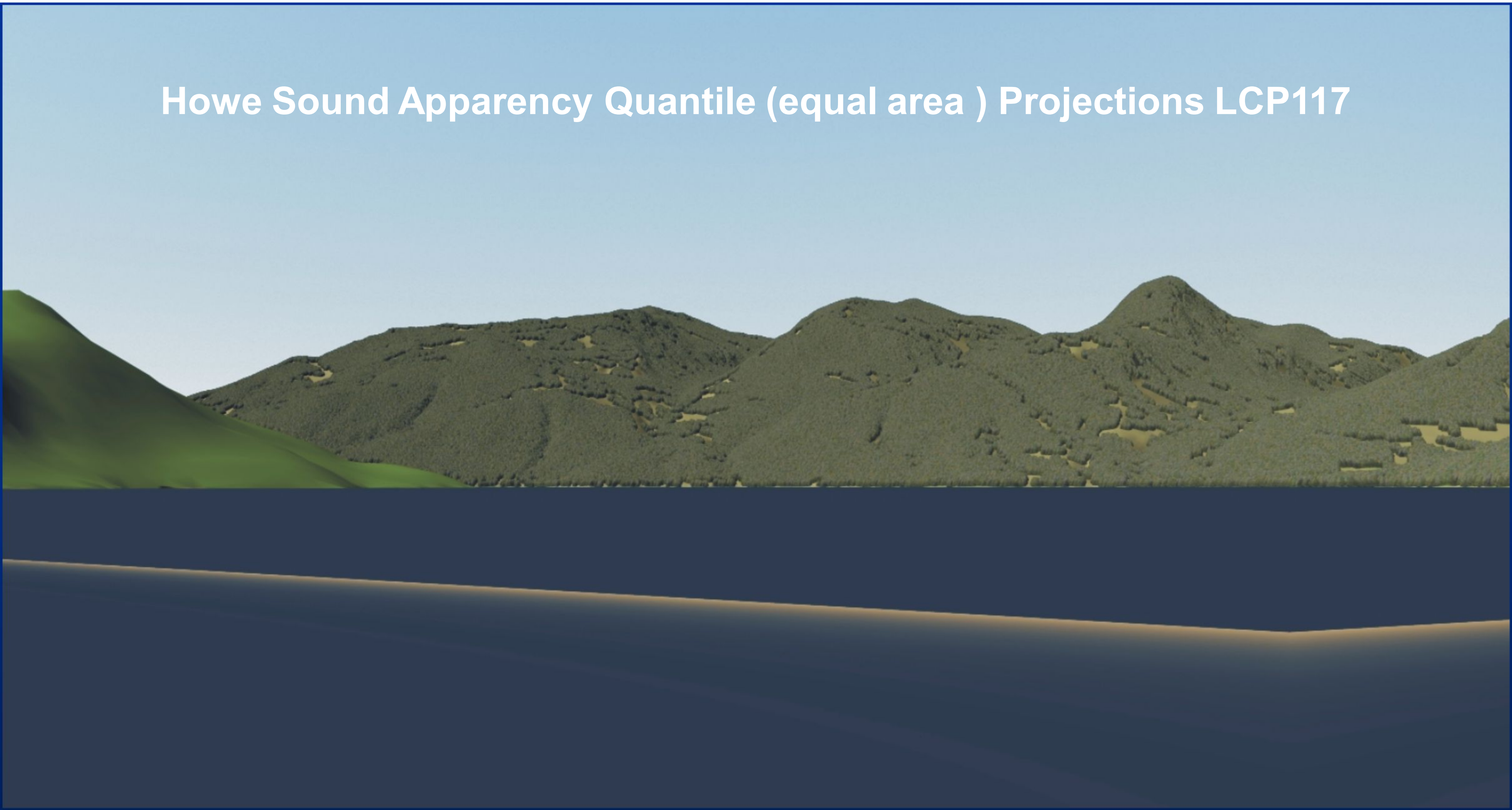
Quantile / Risk	Plan (%)	Pers. (%)	P2P
2 / L	12	0.2	89:1

Howe Sound Apparency Quantile (equal area) Projections LCP117



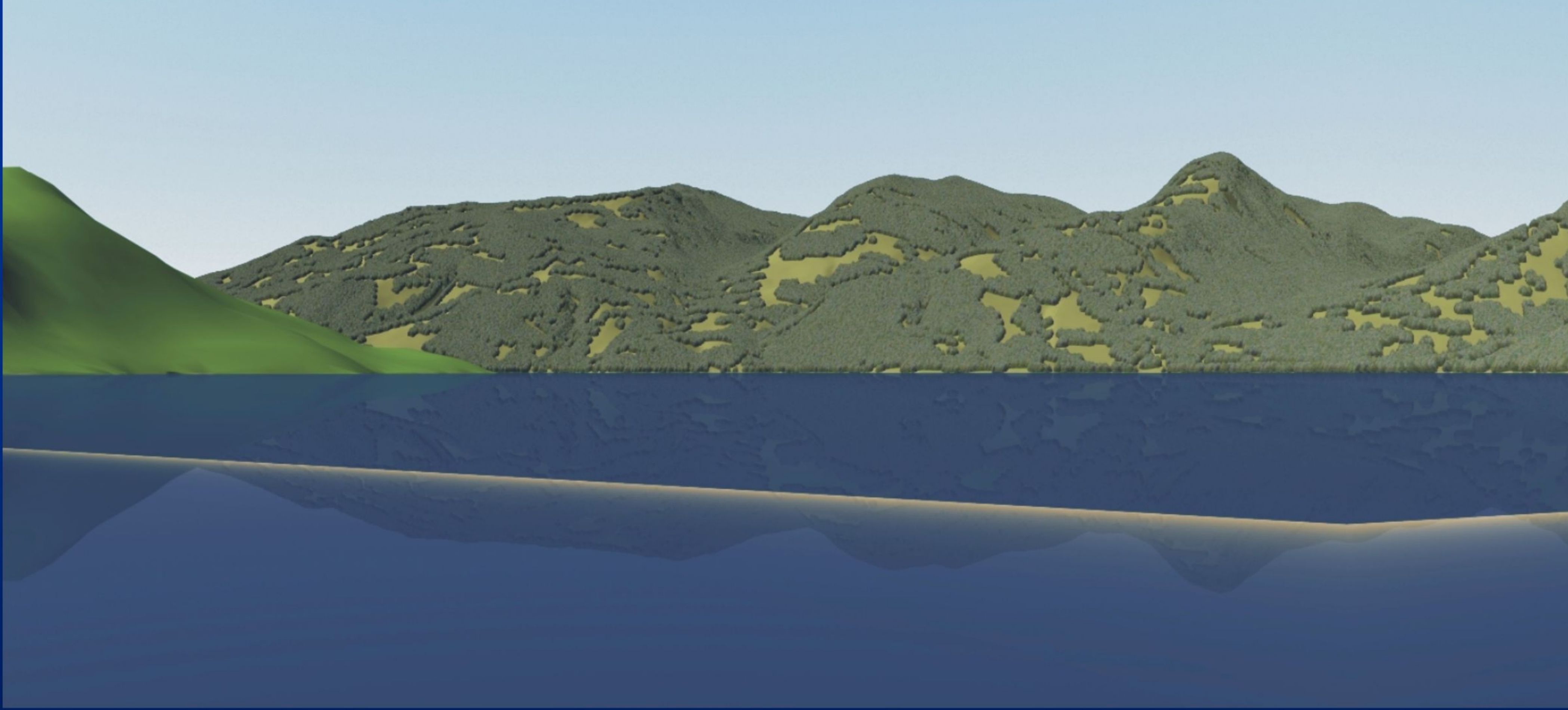
Quantile / Risk	Plan (%)	Pers. (%)	P2P
3 / ML	13	1	13:1

Howe Sound Apparency Quantile (equal area) Projections LCP117



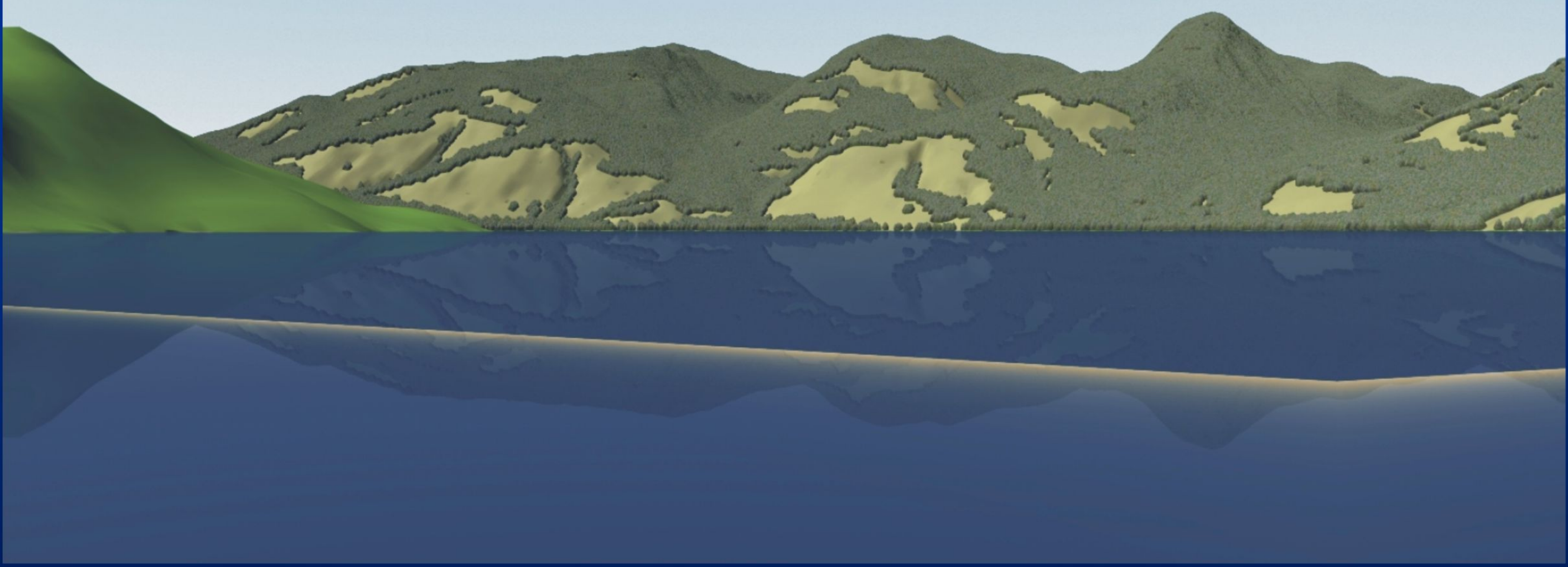
Quantile / Risk	Plan (%)	Pers. (%)	P2P
4 / MH	17	2.2	8:1

Howe Sound Apparency Quantile (equal area) Projections LCP117



Quantile / Risk	Plan (%)	Pers. (%)	P2P
5 / H	21	6.1	3.4:1

Howe Sound Apparency Quantile (equal area) Projections LCP117



Quantile / Risk	Plan (%)	Pers. (%)	P2P
6 / VH	26	50	0.5:1

Howe Sound Aggregated Apparency Quantile Projections
LCP117

Aggregating Quantiles

1

1+2

1+2+3

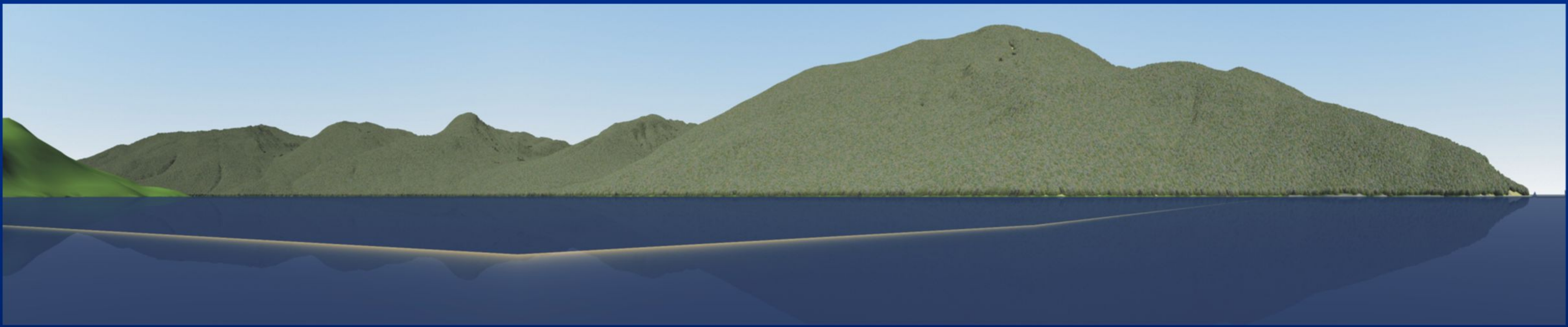
1+2+3+4

1+2+3+4+5

ALL

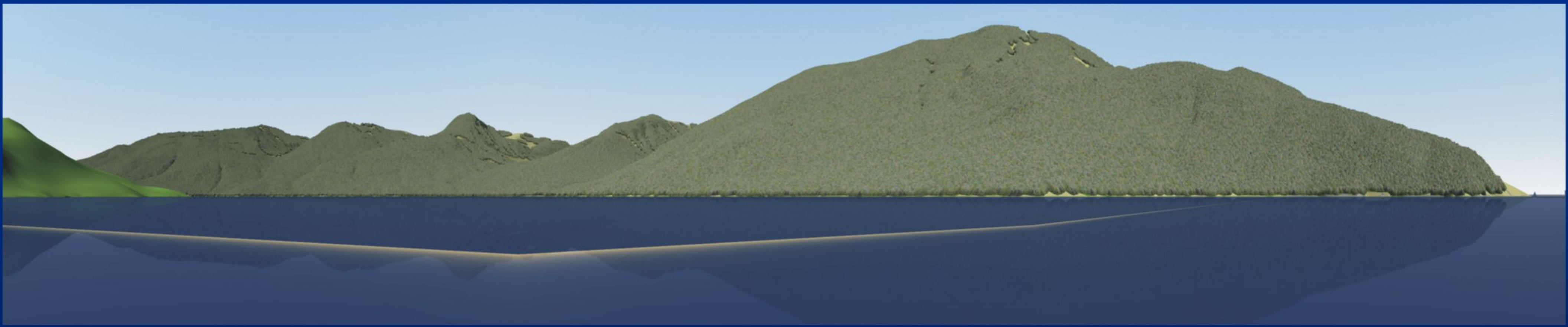
Default Forest Cover

Howe Sound Aggregated Apparency Quantile Projections LCP117



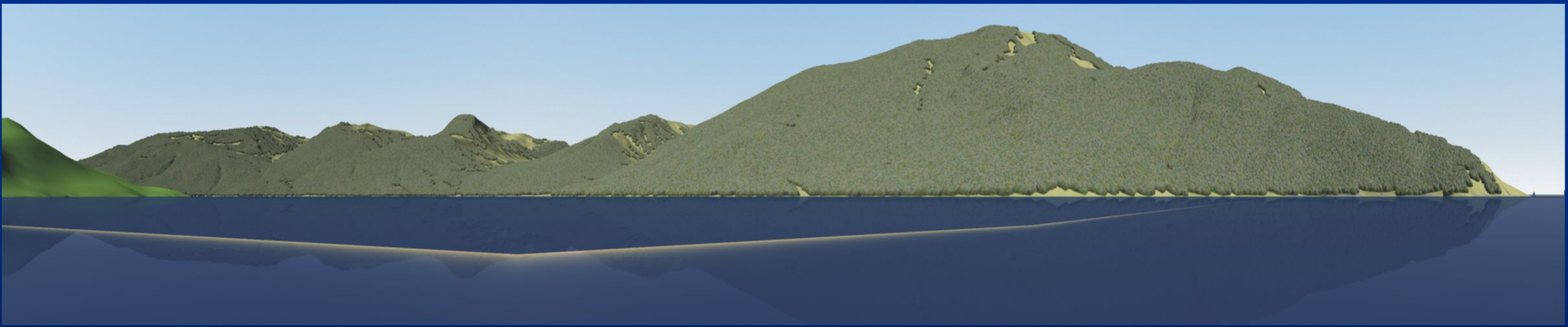
Quantile / Risk	Plan (%)	Pers. (%)	P2P
1 / VL	11	0.05	218:1

Howe Sound Aggregated Apparency Quantile Projections LCP117



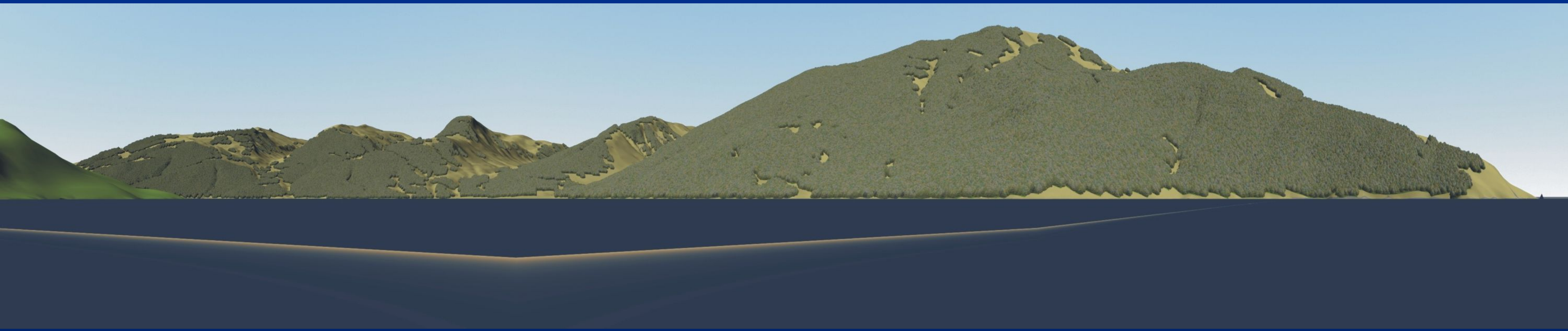
Quantiles / Risk	Plan (%)	Pers. (%)	P2P
1-2 / VL-L	23	1	23:1

Howe Sound Aggregated Apparency Quantile Projections LCP117



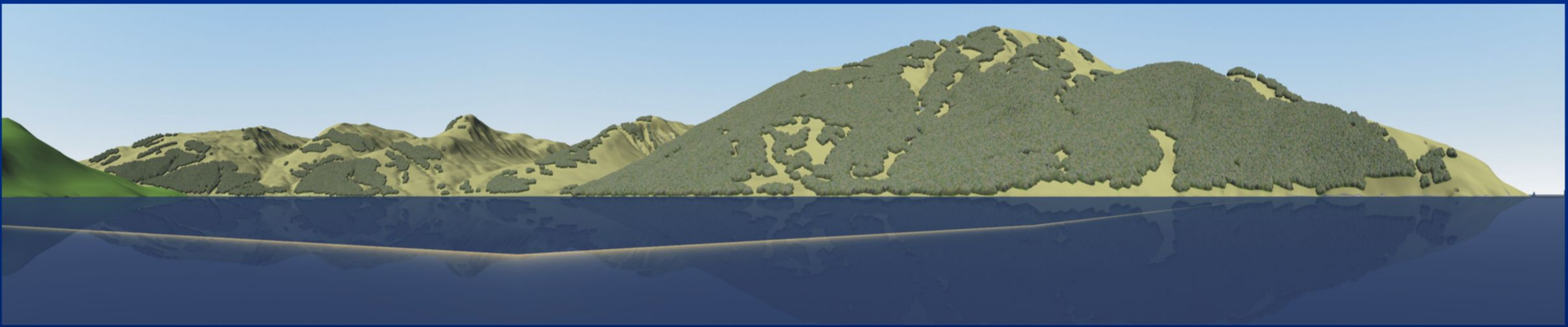
Quantiles / Risk	Plan (%)	Pers. (%)	P2P
1-3 / VL-L-ML	36	4.3	8:1

Howe Sound Aggregated Apparency Quantile Projections LCP117



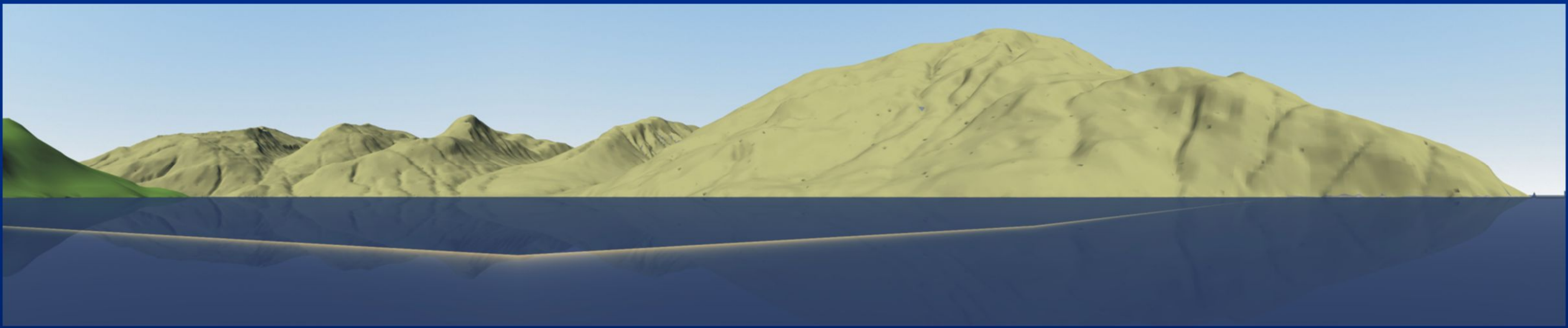
Quantiles / Risk	Plan (%)	Pers. (%)	P2P
1-4/ VL-L-ML-MH	53	12	4:1

Howe Sound Aggregated Apparency Quantile Projections LCP117



Quantiles / Risk	Plan (%)	Pers. (%)	P2P
1-5 / VL-L-ML-MH-H	74	28	2.6:1

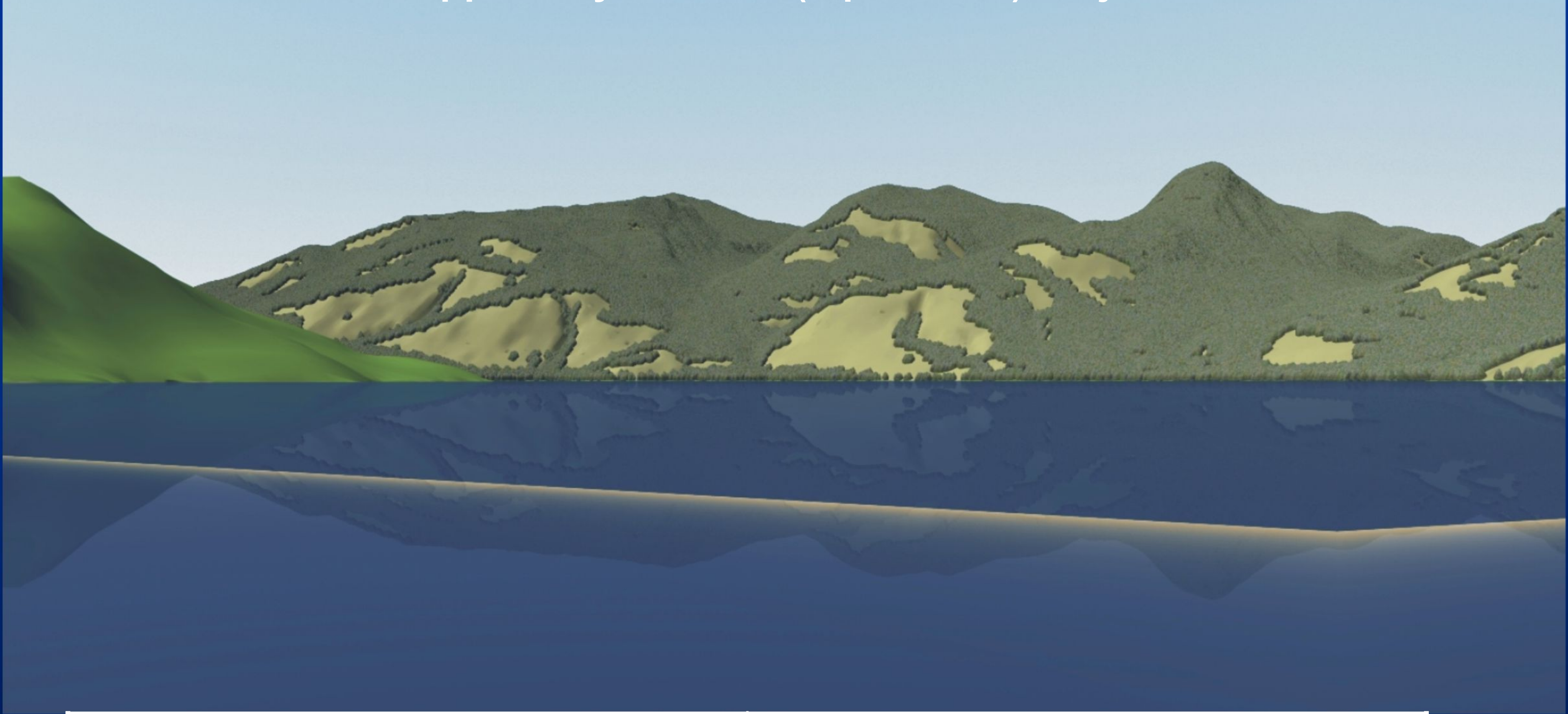
Howe Sound Aggregated Apparency Quantile Projections LCP117



Model Validated – all trees taken

Quantiles / Risk	Plan (%)	Pers. (%)	P2P
1-6 / All	100	100	1:1

Howe Sound Apparency Quantile (equal area) Projections LCP117

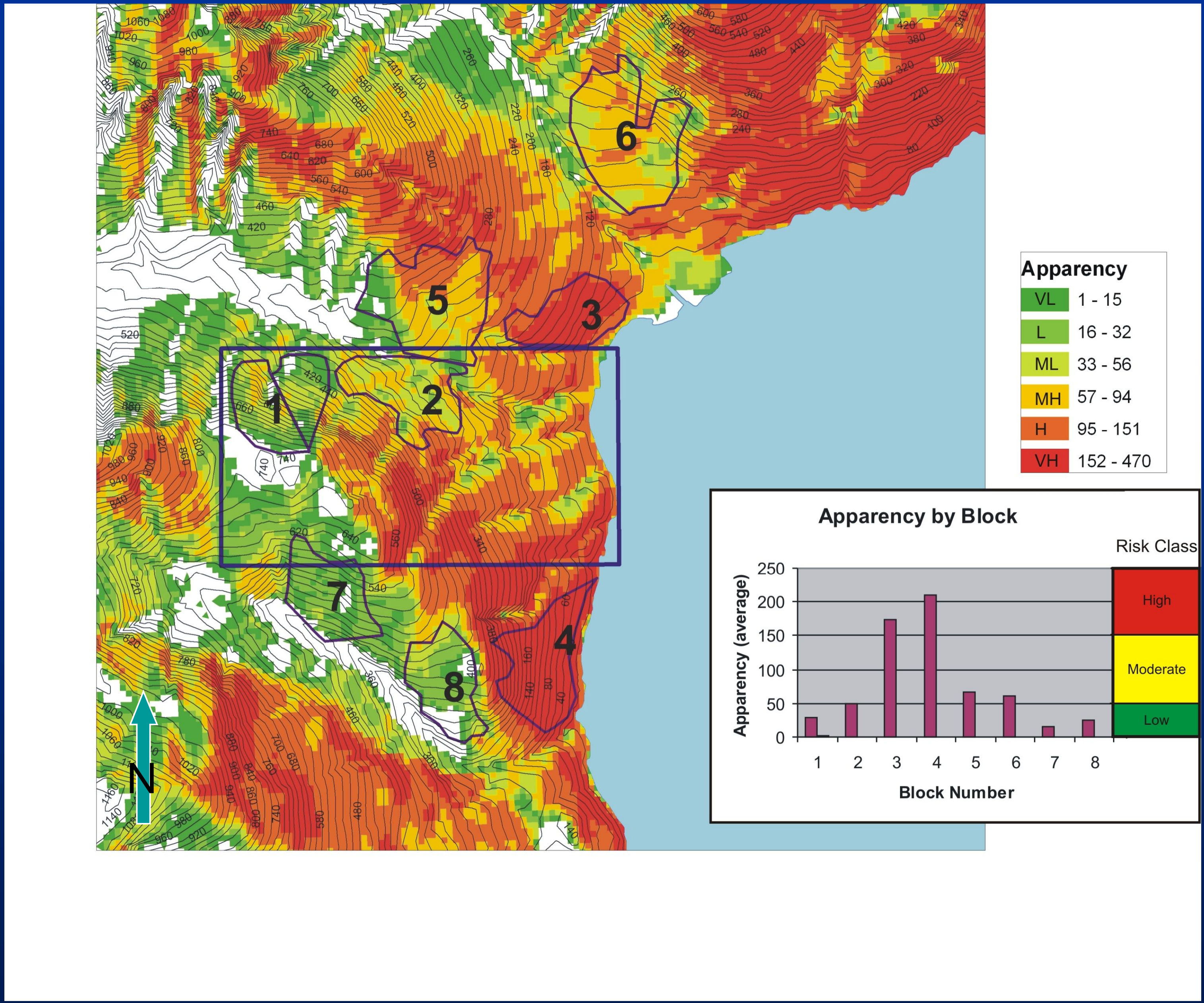


Conclusions of Howe Sound Test	Limitations
Consequences of apparency	Not a plan; no design
Learning opportunity with landbase	No other constraints at this point
Detailed P2P with tree screening	Generic forest
inherent design; lines of force, etc.	DEM limitation – accuracy/resolution

Test Area 1 – Howe Sound

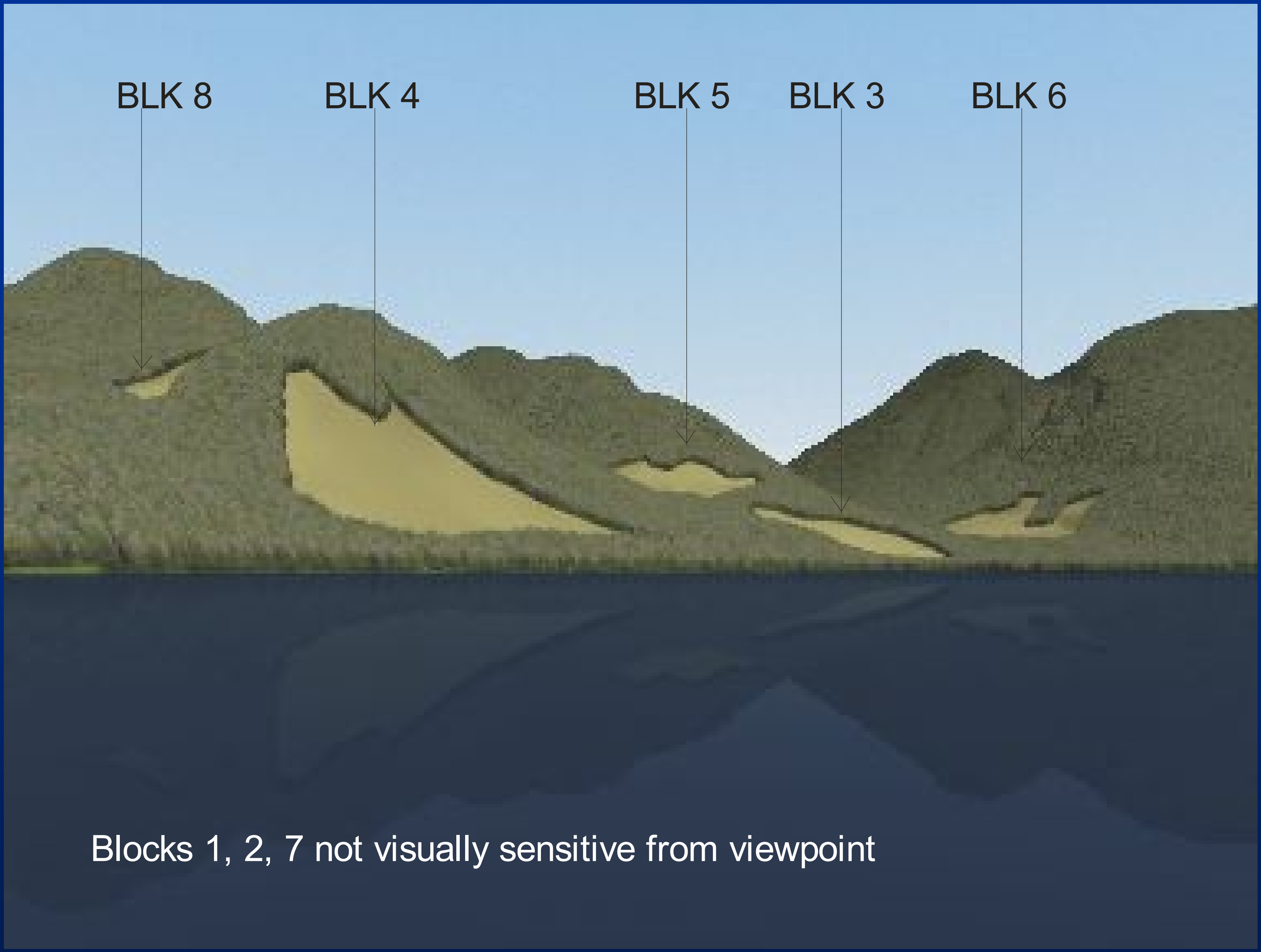
B. Harvest Layout Trial –

Using Apparency as a Test, Assisting Manual Design



Howe Sound Harvest Cutblock Location Test

Figure 101 Howe Sound harvest cutblock location test in higher and lower cumulative apparency areas, with average apparency calculated per cutblock, and coded by risk class (high, medium, low).



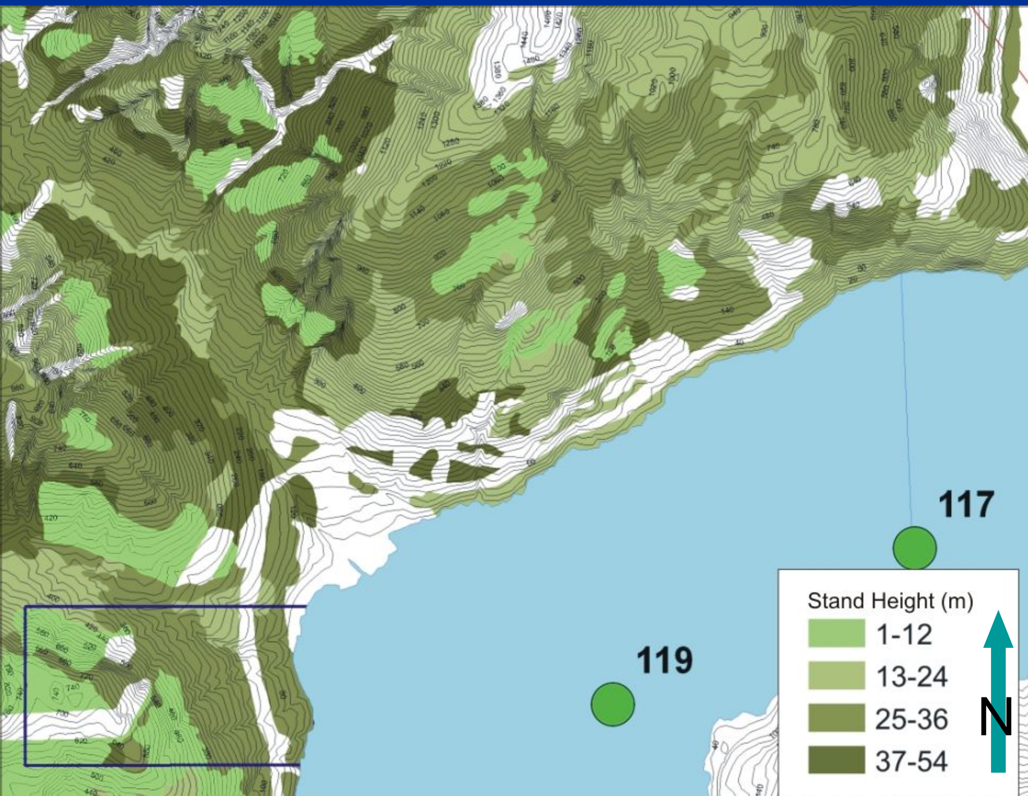
Howe Sound Harvest Cutblock Location Test

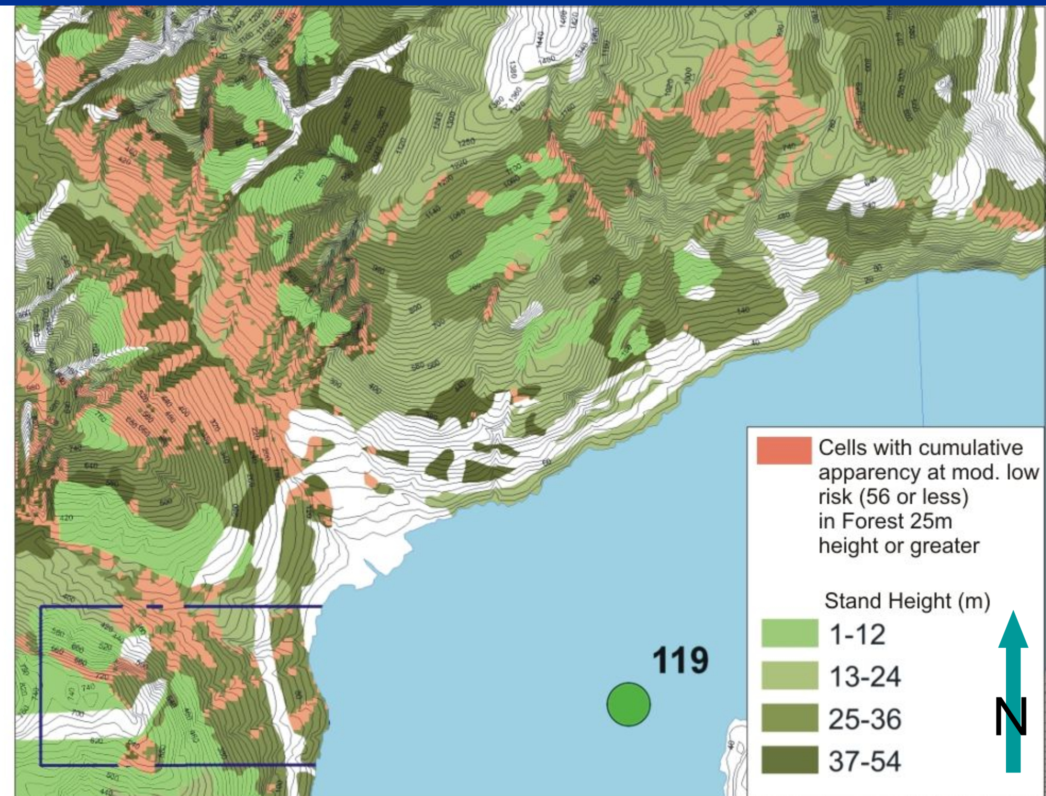
Figure 104 Trial cutblock locations selected by levels of apparency; appearance from LCP 119.

Test Area 1 – Howe Sound

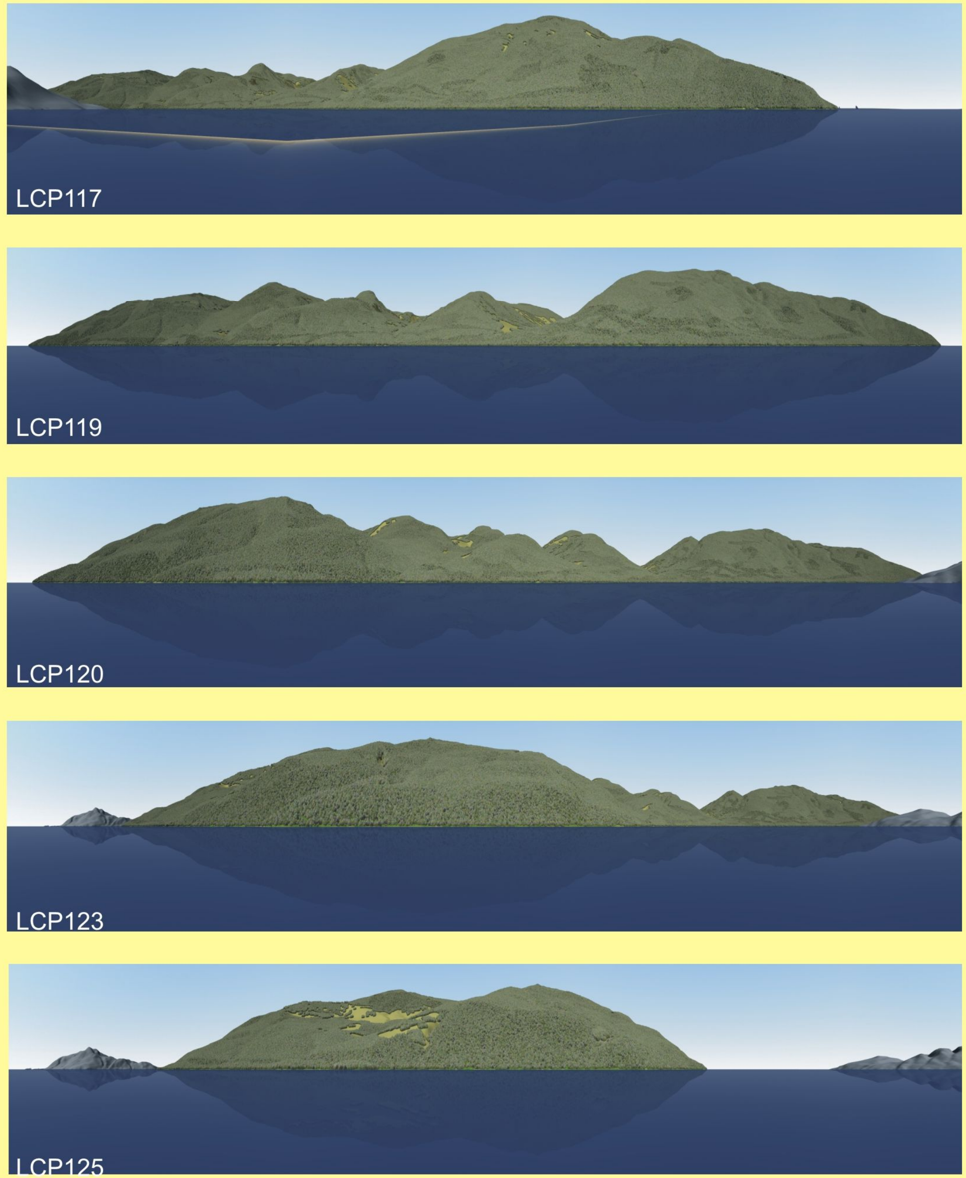
C. Apparency-Forest Cover Selection Trial to Test Integration with Other Resources

– Finding Low Visual Risk Mature Timber as Provided from Vegetation Resources Inventory





Cell selection by tree height attribute (25m or greater) and moderately low or low apparency (visual risk) in ArcMap (right image: selected cells in pink).



Howe Sound Grid Cells with Forest Heights >=25m and Apparency <=56 (moderately low visual risk or less)
999 ha. of 5024 ha.(19.9%) in cumulative visible landbase

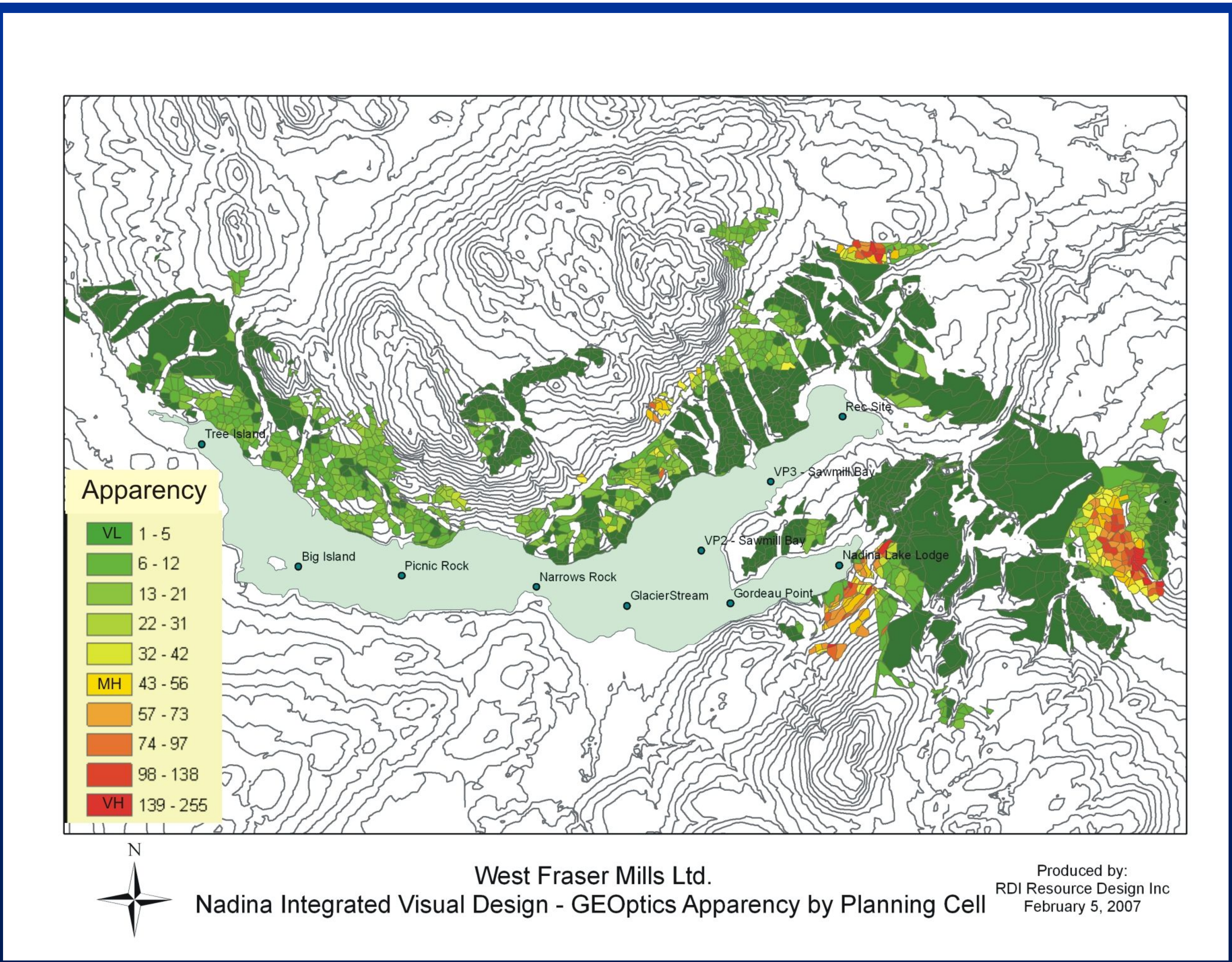
Cell selection by tree height attribute, Howe Sound model, all viewpoints
Visual results, if selected cells were harvested,
grid cells selected by forest height from VRI, 25m height or greater,
and cumulative apparency, moderately low to very low visual risk).

Conclusions of Howe Sound Tests	Limitations
Selecting by apparency and forest height	Not a plan; no design
Consequences of apparency	No other constraints at this point
Learning opportunity with landbase	
Correct P2P with tree screening using actual forest cover	
inherent design; lines of force, etc.	

Test Area 2 – Nadina Lake

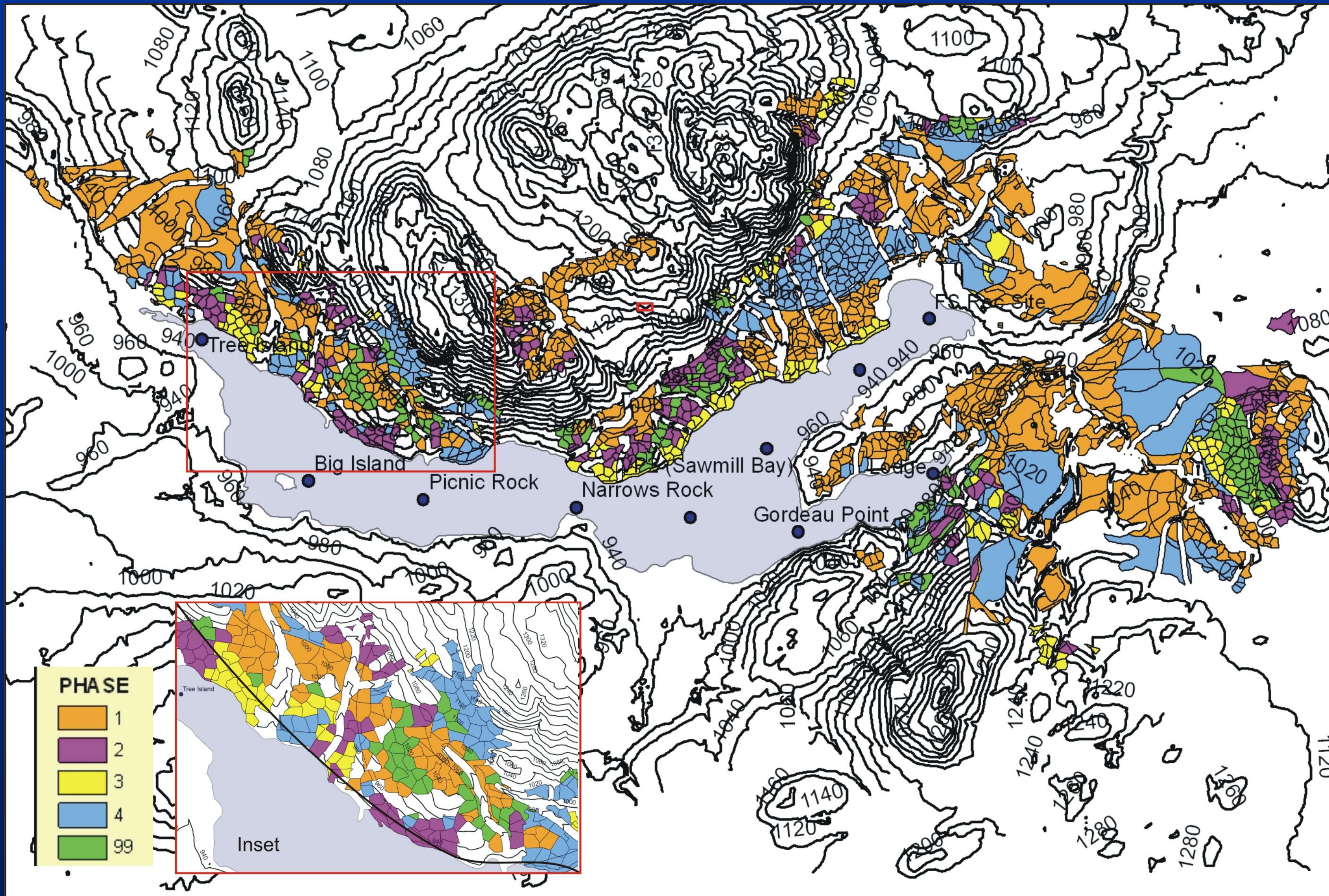
A. Integrated Visual Design Plan to provide full rotation harvest plan of beetle infested timber, using apparency to guide scheduling and design
Four 20-year passes

(RDI Commercial Application)



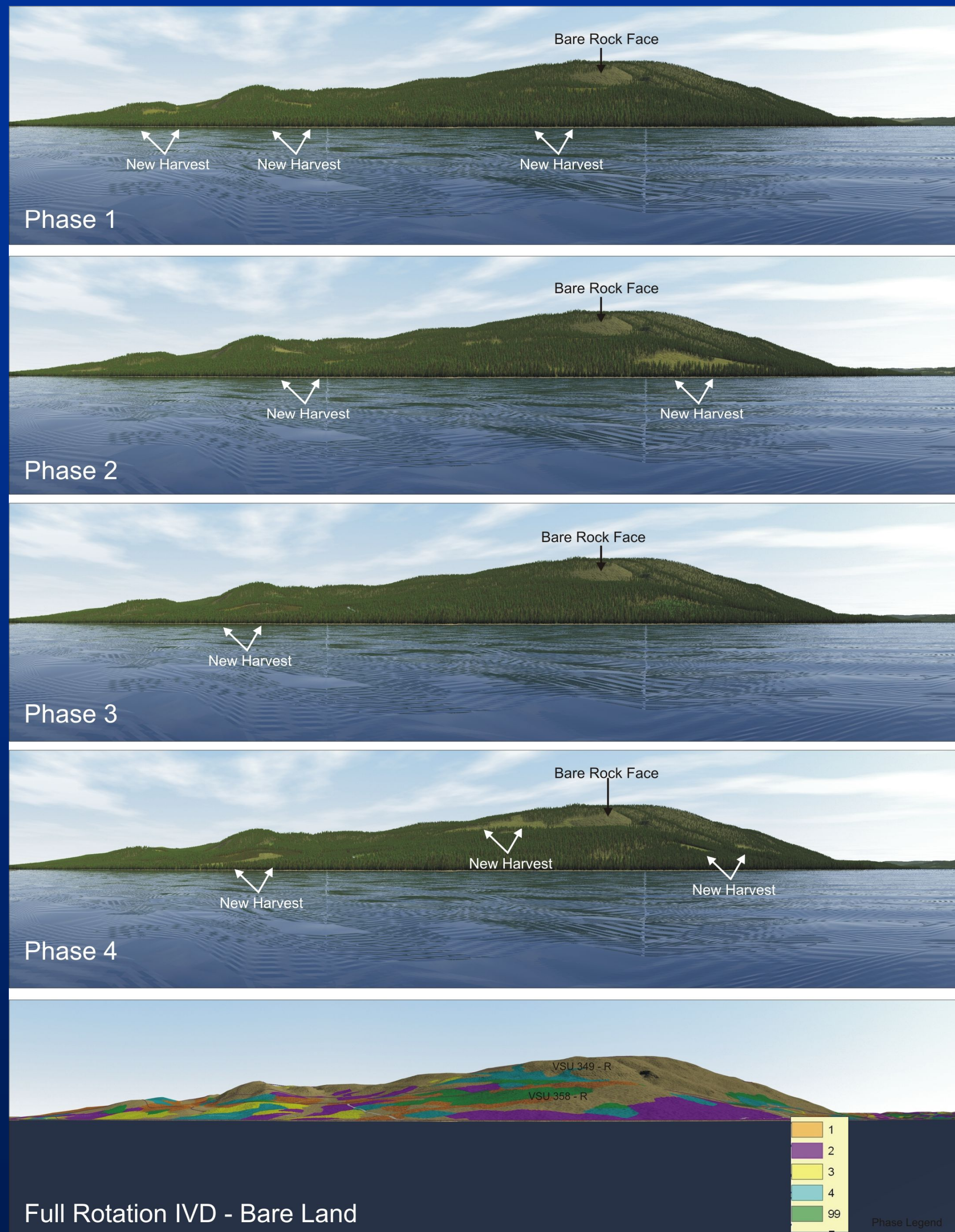
Nadina Lake Integrated Visual Design Plan

Figure **83 Apparency value is assigned to each potential harvest unit to provide guidance when scheduling the units for harvest phase.**



Nadina Lake Integrated Visual Design Plan

Figure 84 Four pass scheduling to meet VQOs applied to treatment units based on cumulative apparency and iterative testing with perspective visualizations, with inset showing closer view of treatment units; Class 99 units were not set to a schedule.



Nadina Lake Integrated Visual Design Plan

Figure 85 Four-pass schedule projected from the Big Island viewpoint, with all phases shown in bare land image at bottom, with legend. Phase 99 (not scheduled for harvest) is evident in the bottom image, classified by phase.

Conclusions of Nadina Tests	Limitations
Actual plan with all constraints Apparency informed scheduling and design Learning opportunity with landbase Detailed P2P with tree screening	Requires expert design intervention DEM resolution Viewpoint selection

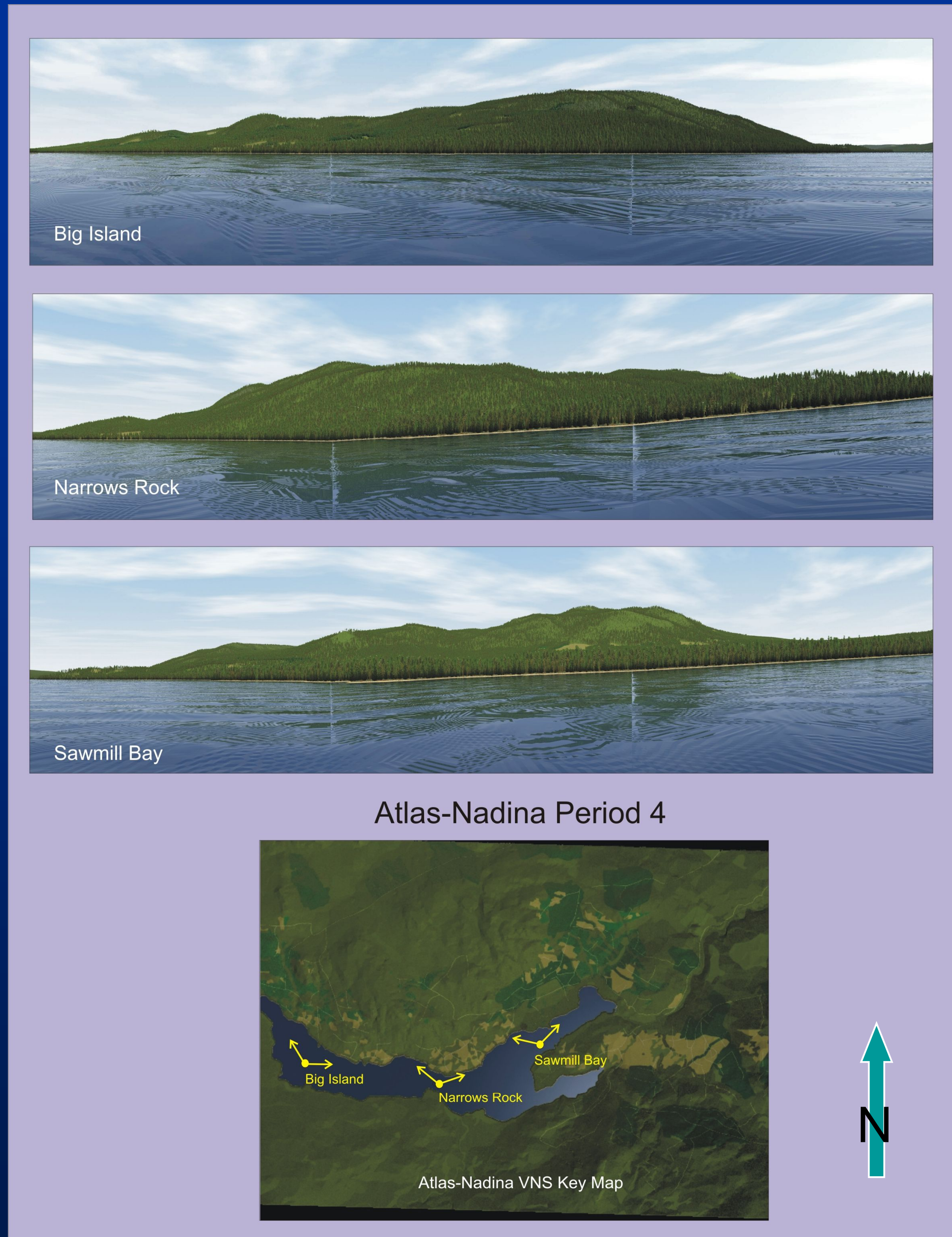
Test Area 2 – Nadina Lake

B. Atlas-GEOptics Automated Landscape Design Plan

to determine efficacy of a harvest scheduler program (Atlas) using apparency

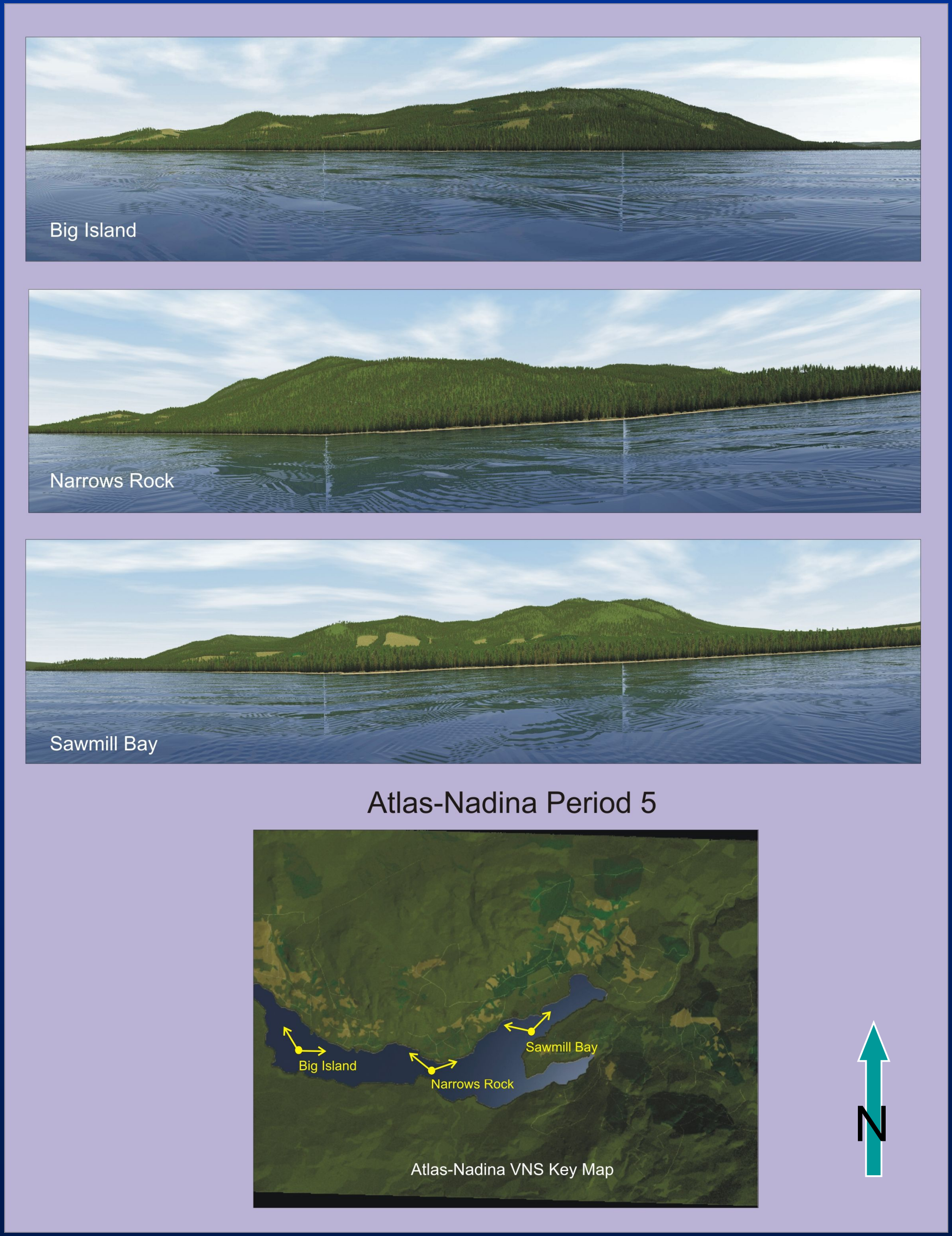
12 – 20 year Periods – 150,000 m3 each

Forest Cover Attributes from Vegetation Resource Inventory



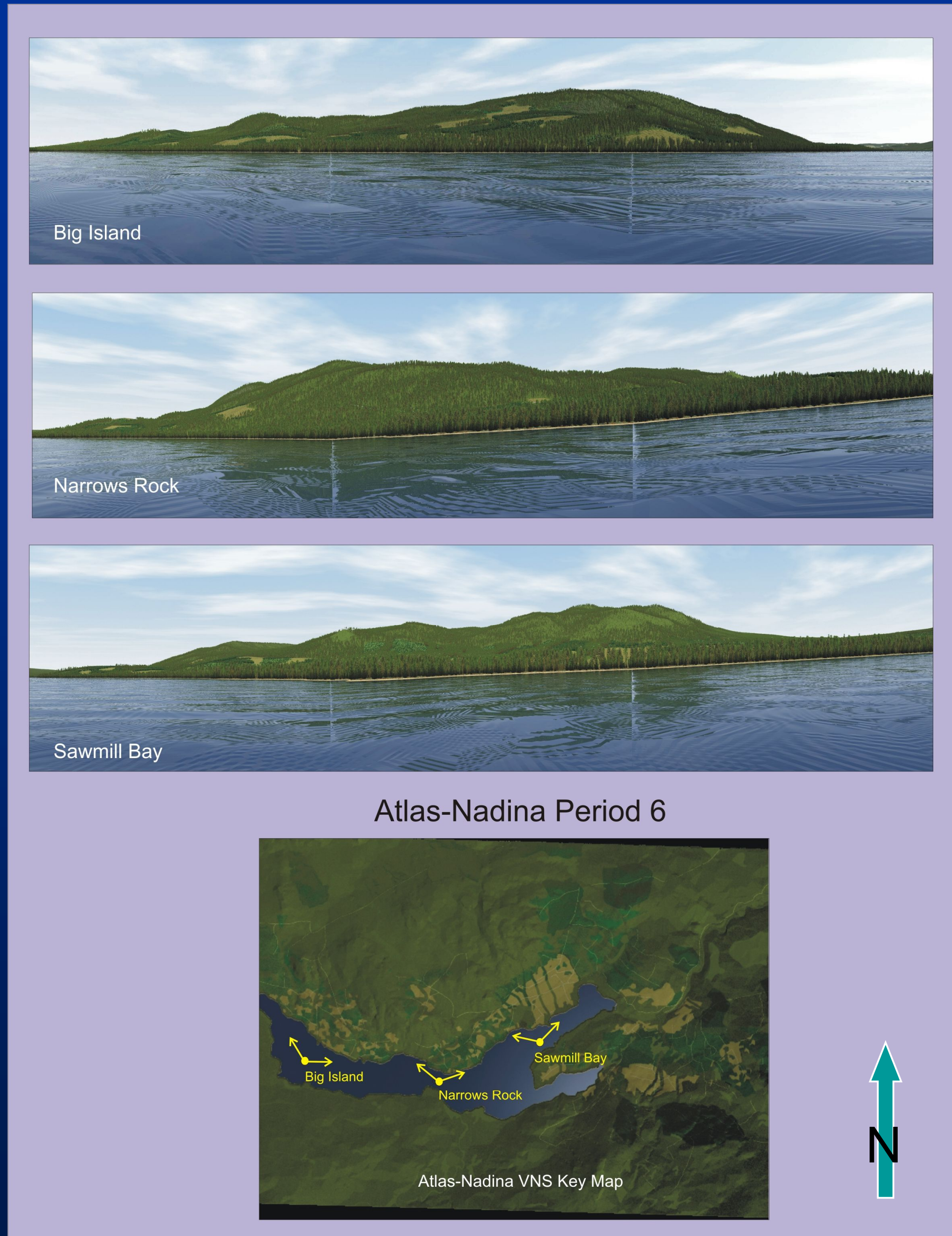
Automated Design using Forest Planning Studio (ATLAS)

Figure 92 Atlas-Nadina automated harvest schedule - Period 4.



Automated Design using Forest Planning Studio (ATLAS)

Figure 92 Atlas-Nadina automated harvest schedule - Period 5.



Automated Design using Forest Planning Studio (ATLAS)

Figure 92 Atlas-Nadina automated harvest schedule - Period 6.

Conclusions of Nadina Automation Tests	Limitations
Actual plan with all constraints	DEM resolution
Apparency informed scheduling and design	Constraint data
Learning opportunity with landbase	
Detailed P2P with tree screening	
Replaced trial and error	
Supplemented expert design	

9.2 External Testing - Focus Groups

9.2 External Testing - Focus Groups Questionnaire and Discussions

Three Sessions

- Richmond (7): All 5 BCMOFR VRM Practitioners
- UBC (5): Academics, Students, Managers
- Nanaimo (4): MOFR and Industry Managers

Three Part Questionnaire

- Opinion survey (19 Questions)
- Written Discussion (6 topics provided)
- Verbal Discussion (recorded)

Questionnaire Components

1. Opinion Survey Question Groups:

Part A. Presentation Effectiveness (6)- how presented
Part B. Mapping Effectiveness (4) – product perception
Part C. Applications; Advantages; Disadvantages (9)

Questionnaire rating scale

-2	-1	0	+1	+2
Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree

Questionnaire

A. Effectiveness of the Presentation (examples)	A V G
5. The possible benefits of the GEOptics landscape apparency method were clearly outlined.	
6. The possible limitations of the GEOptics landscape apparency method were clearly outlined.	

Questionnaire

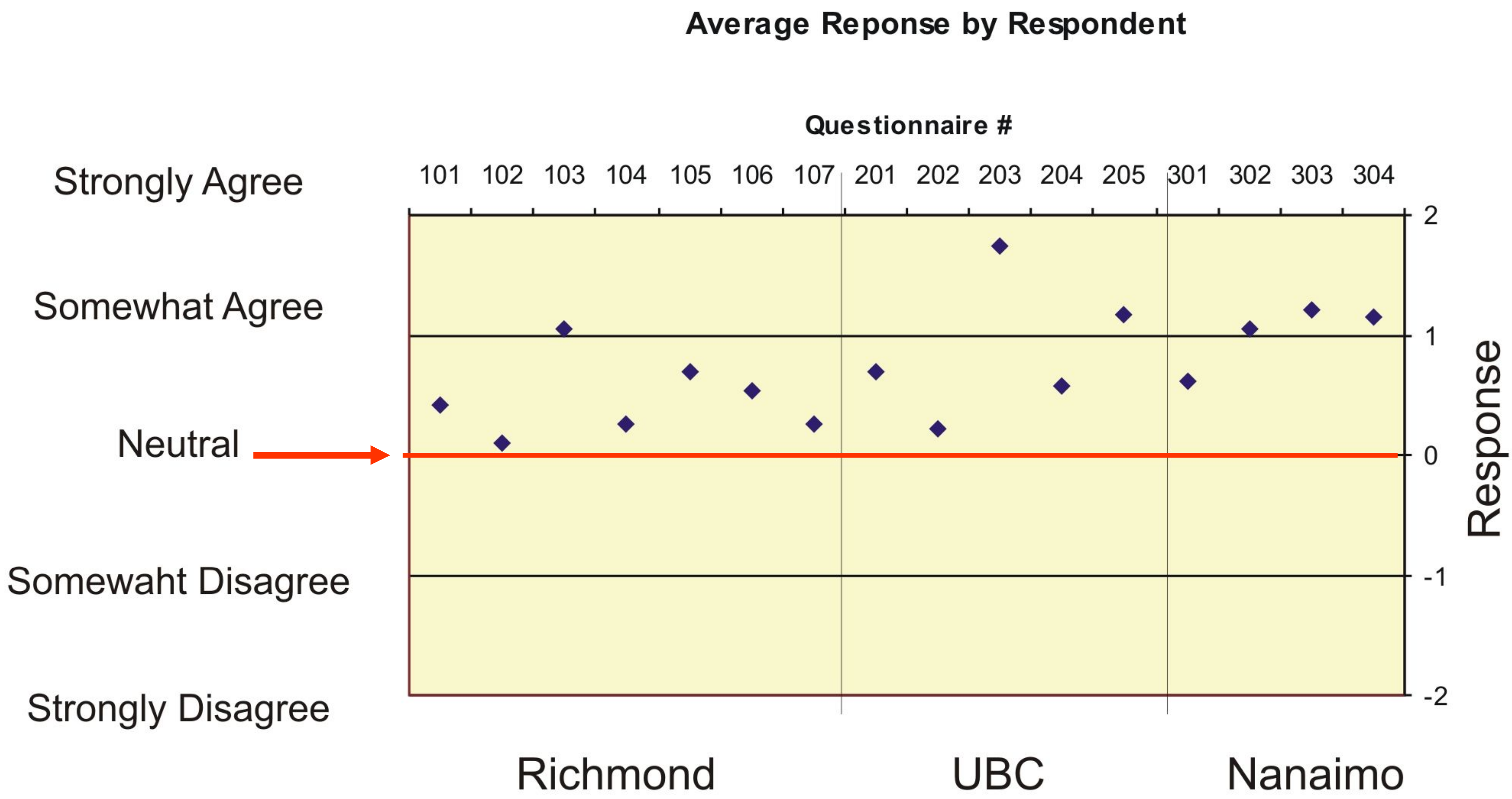
B. Effectiveness of the Landscape Apparency Mapping (examples)

9. The GEOptics output appeared to be compatible with conventional GIS resource analysis.	
10. The GEOptics output appeared capable of providing the degree of detail and accuracy necessary for consideration in resource planning and decision-making.	

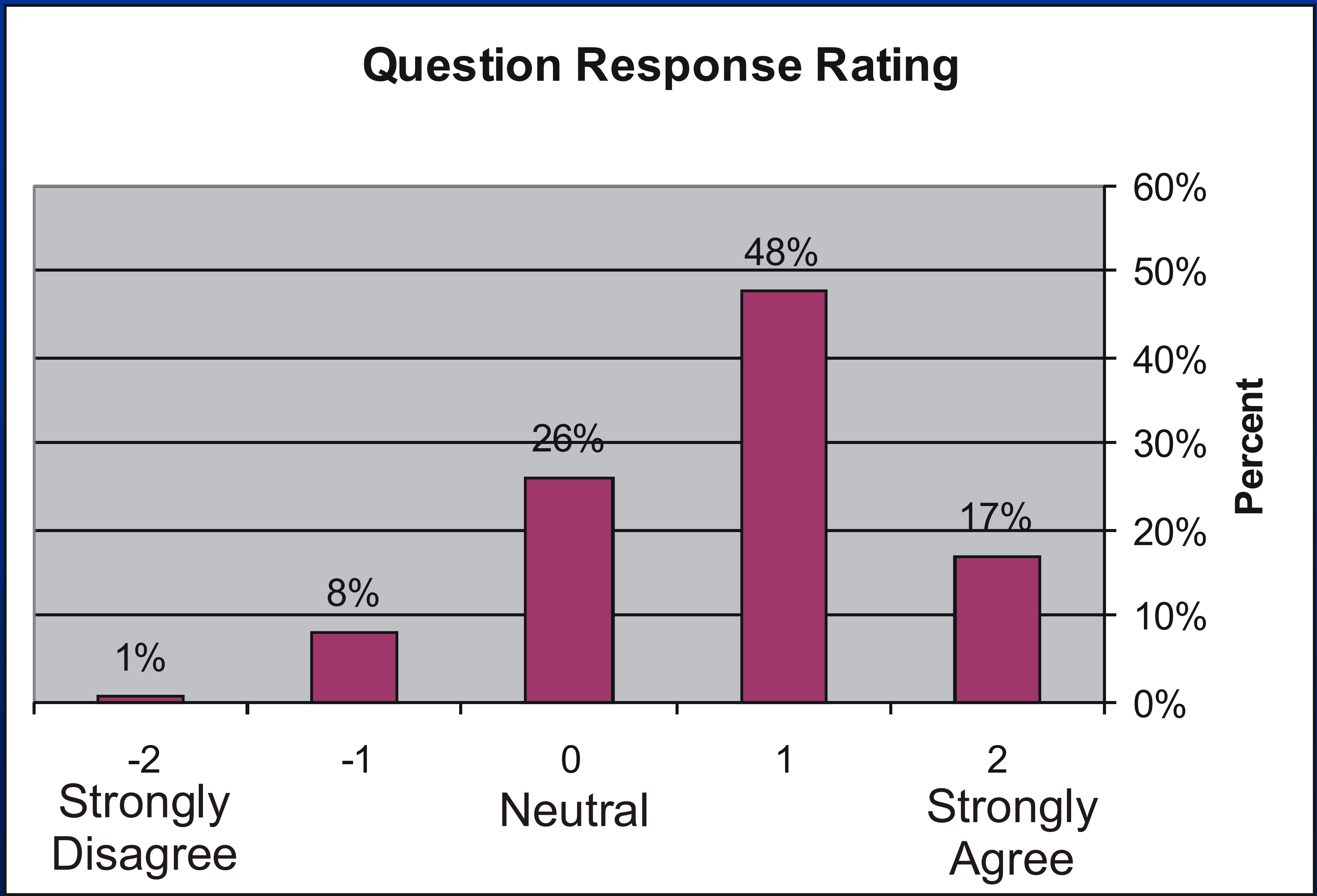
Questionnaire

C. Potential Applications, Benefits or Disadvantages of Methods (examples)

17. GEOptics output could be well suited for total chance integrated visual design over the long-term.	
19. The GEOptics method could provide greater flexibility for managing visually constrained areas relative to conventional VLM.	



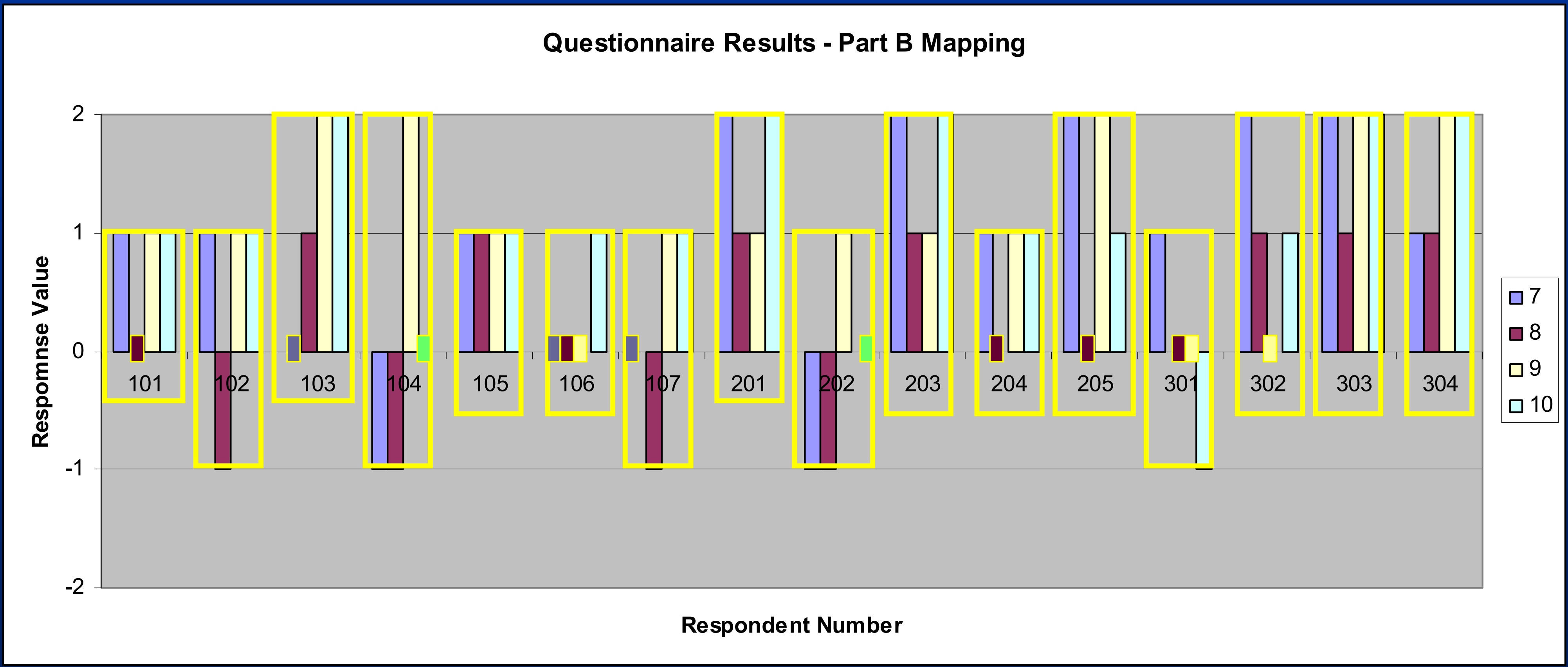
Overall Average Response to All Questions by each Respondent was Positive



65% of Responses to all Questions Agreed (1,2)
26% were Neutral*; 9% Disagreed (-1, -2)

***Includes four "no answers" taken as Neutral)**

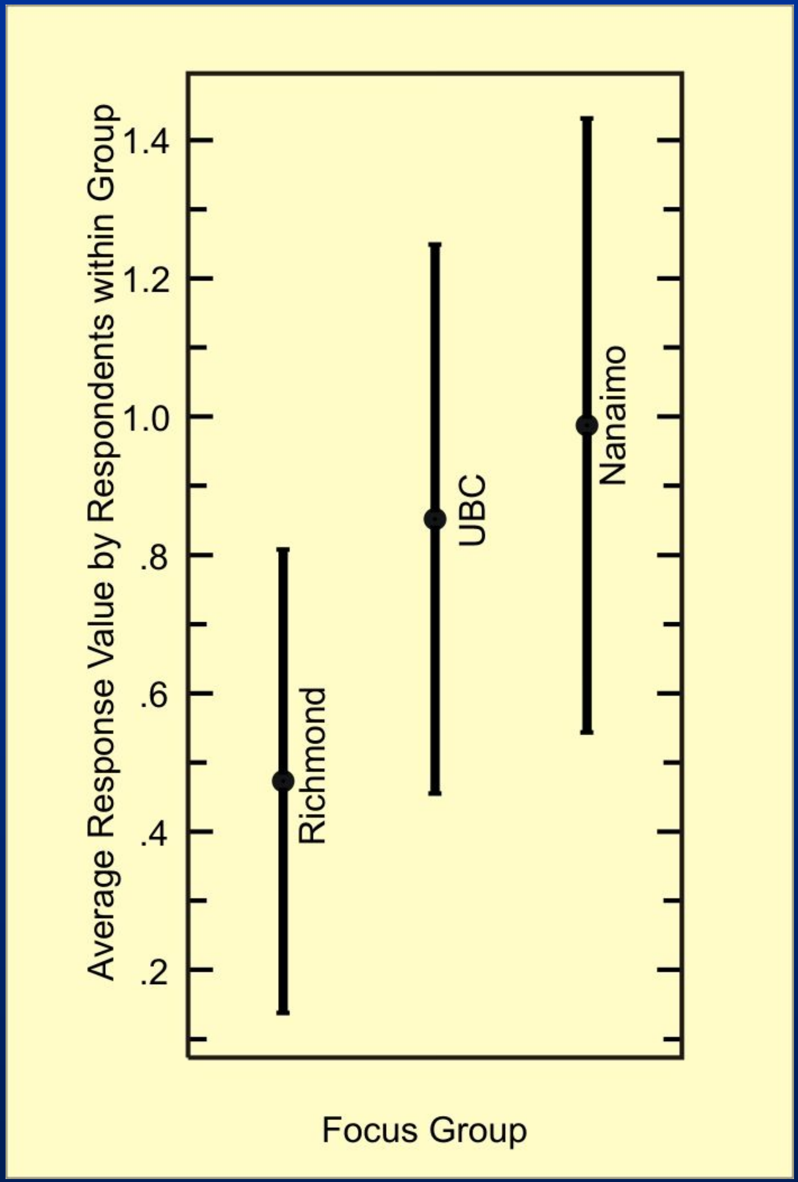
Response rating results: Questionnaire Part B Mapping



Question 7: Easy to Understand (pale blue)
Question 8: Easy to Apply (pale purple)
Question 9: Compatible with GIS (pale yellow)
Question 10: Detail for decision-making (pale green)
Full set by individual outlines in yellow
Zero ratings indicated with small boxes (on "0" line)

Questionnaire Results

Averages by Question Group	
Part A. Presentation	0.71
Part B. Mapping	0.85
Part C. Applications	0.69
Averages by Focus Group	
Group 1. Richmond (n=7)	0.47
Group 2. UBC (n=5)	0.88
Group 3. Nanaimo (n=4)	1.01
Overall (n=16)	0.73



Plot of focus group means with 95% confidence intervals, respondent’s averages for all questions, and with centre dot the average per group, non-significant differences (null hypothesis = 0.13).

Focus Group Discussion

The 6 discussion topics were:

1. **Possible advantages relative to conventional VLM methods?**
2. **Possible disadvantages relative to conventional VLM methods?**
3. **How could apparency mapping be used by resource managers to enhance conventional visual landscape planning and design?**
4. **How could apparency be used by resource managers as a component of Timber Supply Planning?**
5. **How might the apparency method be improved or made more useful?**
6. **Any other issues or concerns raised in the session?**

Focus Group Discussion Results (sample)

103 (+) *"Tells licencees where they can clearcut without affecting VQO, e.g. quantile 1-3 (lowest out of 6 apparency classes)."*

205 (+)*"Greater precision, refinement, resolution. Move away from binary outputs*

305 (-) *"Complexity; planning time; increased operational costs."*

102 (-) *"Need some special tools to do this work, i.e., VNS."*

203 (+) "Seems very useful in planning sequence of passes."

304 (+) *"Seems to easily dovetail into other strategic land management resource layers used at a landscape level planning process."*

105 (-) *"Needs to be proven that results generated from GEOptics outperforms conventional existing methods. We have a VIA (visual impact assessment) process in place used by many consultants."*

107 (+/-) *"GEOptics is a good model for showing what might be possible. TSR (timber supply review) must model what is current practice. The two might not be the same."*

10. Discussion and Conclusions

Improving the Worth of EVA

✓**Utility:**
- ✓Quick to prepare the illumination map
- ✓Industry commonly has access to VNS/ArcGIS
- ✓Single/Cumulative apparency options – build as you go
- ✓Generalizable and compatible with other systems

✓**Sensitivity**
- ✓Very sensitive to viewing angle changes
- ✓Very sensitive to number of viewpoints (light)

✓**Accuracy**
- ✓TRIM common digital terrain map base
- ✓Can use refined topography as available

✓**Precision**
- ✓All users will obtain same results if correctly set up
- ✓Validated by ArcGIS viewshed

Potential improvement to the BCMoFR VLM system using GEOptics apparency

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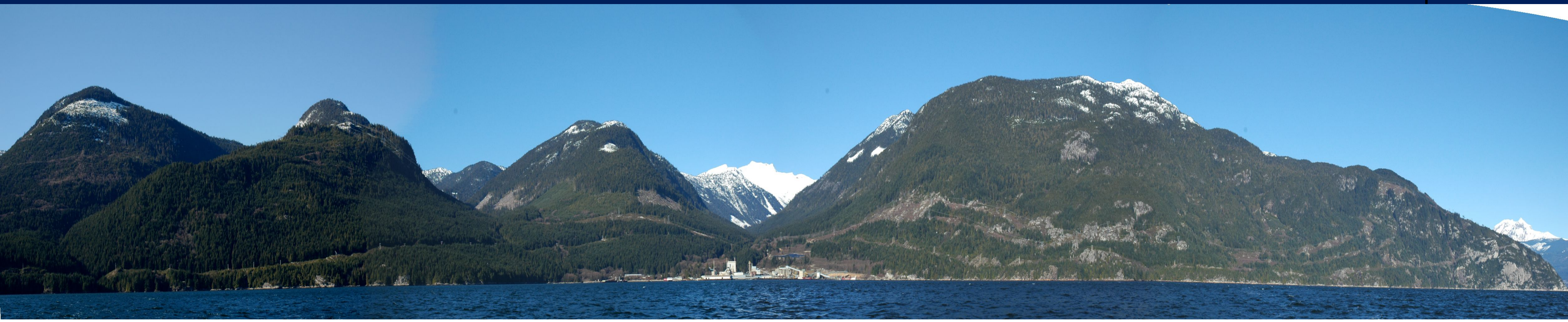
VLM Phase 1 VLI	VLM Phases 2-3 Analysis	VLM Phase 4 Design
VAC rating and map factor	VQO Apparency Class P2P weighting factor within VSU Entered in TSR for each VSU (bottom-up)	Apparency map values separates challenging from easy areas within VSUs and guide design and operations Guide to visual impact assessment in advance Hierarchical integrated planning element

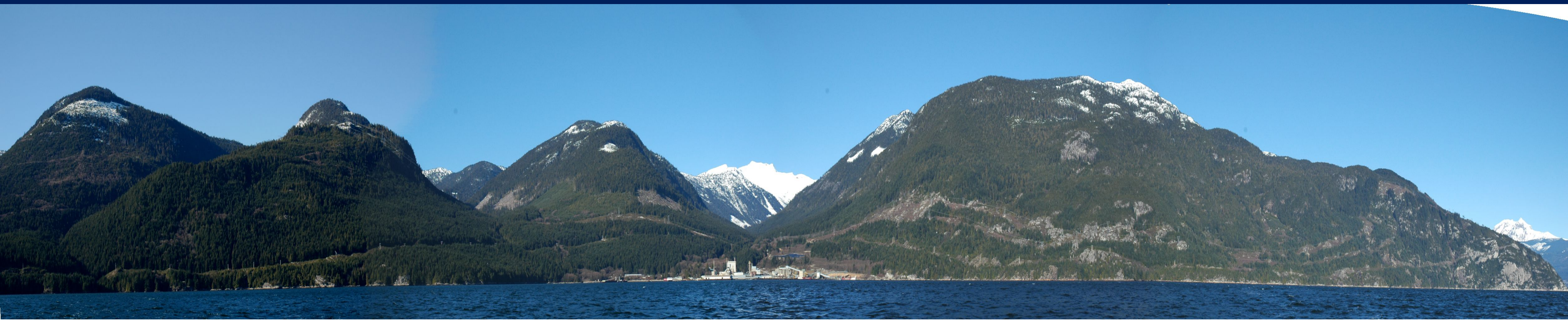
Achievements of the Apparency Model

✓More precise understanding of visual risk within VSU
✓Integrated tool linking viewer and landscape
✓Inherent understanding of landscape
✓Informs users' understanding of visual impact potential
✓Visual Design "guide"
✓Efficient "automation"
✓Precise P2P factors may improve available wood supply
✓Adaptable to other GIS tools
✓Adaptable to other jurisdictions
✓Helpful, compatible with conventional mapping
✓Well-suited to integrated planning



Limitations of GEOptics apparency

✓New tool – requires learning
✓Shadow map/viewshed validation
✓Possibly new computer program(s)
✓DEM resolution; accuracy
✓Not replacement for design expertise
✓More trials required in more landscape types
✓Perceived as too complex - streamline
✓Caution with timber supply analysis – coarse by intent
✓Resistance to change; new concepts



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