

# Data-driven, early-exploration predictive indicators for porphyry-style mineralization in Yukon using deconstructed \*weights of evidence modeling

**Definitions**  
 Categorical feature/evidential theme: a spatial theme (i.e., data layer) used as evidence for the occurrence of training points. Each categorical feature occupies a defined area.  
 Training points: the set of spatial point objects whose locations are to be predicted. In mineral exploration, these are the sites of known mineral deposits or occurrences - points are either present or absent.  
 Weight: a measure of a categorical feature class as a predictor of training points. Each class is described by a pair of weights labeled + and -.  
 Positive weights (+) indicate that more points occur on the class than due to chance. Negative weights indicate that fewer points occur on the class than due to chance.  
 Contrast: given by W+ minus W-, the contrast measures the strength of the relationship between the training points (mineral occurrences) and the data layer. A large contrast indicates a strong statistical association between the two.  
 Probability of deposit occurrence: the posterior probability of a deposit occurring versus the prior probability of a deposit occurring. A measure >1 denotes an increase in mineral potential.  
 Prior probability: the probability that a unit cell contains a mineral occurrence before considering any spatial evidence.  
 Posterior probability: the probability that a unit cell contains a mineral occurrence after consideration of the spatial evidence.  
 Unit cell: a small unit of area used for defining the probability of occurrence of mineral deposits.

**\*Weights of Evidence (WoE) - simplified mathematical treatment and explanation**  
 1. Known mineral occurrences of the type being sought (porphyry deposits in this case) are used as training data.  
 2. Categorical features (CF, also called evidential themes) - for example bedrock geology, faults, etc. - are then examined with a view to quantifying the spatial relationship (in probabilistic terms) between the CF and the training data.  
 3. Bayes theorem is used to determine the conditional probability of the occurrence of a deposit given:  
 a. The presence of the CF.  
 b. The absence of the CF.  
 4. The Bayes formulas are converted to odds-based formulas (the odds formulation is probability<sup>2</sup>/probability).  
 5. Natural logs (LN) are taken on both sides of the two equations (i.e., the Bayes equations computing the conditional probability of the occurrence of a deposit given the presence and absence of the CF, respectively) and the resulting solutions give the "weights of evidence" for a deposit in terms of (1) the presence (positive) of the CF (W+) and (2) the absence (negative) of the CF (W-). W+ minus W- give the "Contrast".  
 6. The Contrast value indicates how predictive the CF is for the mineral deposit being sought.  
 7. The process is repeated for all CFs used to generate the predictive indicators map.  
 8. The last step involves determining the Posterior Probability of a mineral occurrence for each CF given the Prior Probability.  
 9. The Prior Probability is simply the total number of deposits divided by the number of cells (or blocks). Cell size in this map is 1 m<sup>2</sup> (the "shape area" unit size in ArcGIS) - any cell size can be used with the assumption that not more than one deposit falls within a cell. The Prior Probability remains the same regardless of which CF is being examined.  
 10. The Prior Probability is converted to Prior Odds and then logged (i.e., LN(Prior Odds)), to align the figures with the W+ and W- outputs.  
 11. The LN(Prior Odds) for the CF is calculated by summing the LN(Prior Odds) + positive WoE for single class CFs, or the LN(Prior Odds) + positive WoE (Class 1) + negative WoE (Class 2, 3, ...) etc., for multiclass CFs.  
 12. The LN(Prior Odds) is converted to Posterior Probability by taking the inverse of the natural log (EXP) and applying the inverse of the probability-odds formula noted above.

The map assesses three metrics for each CF:  
 1. The Contrast (or predictiveness) of the CF.  
 2. The Posterior versus Prior Probability of the CF, which provides a measure of how prospective the CF is, and  
 3. The spatial extent of the area occupied by each class of each CF to assist the user when selecting areas for follow-up.

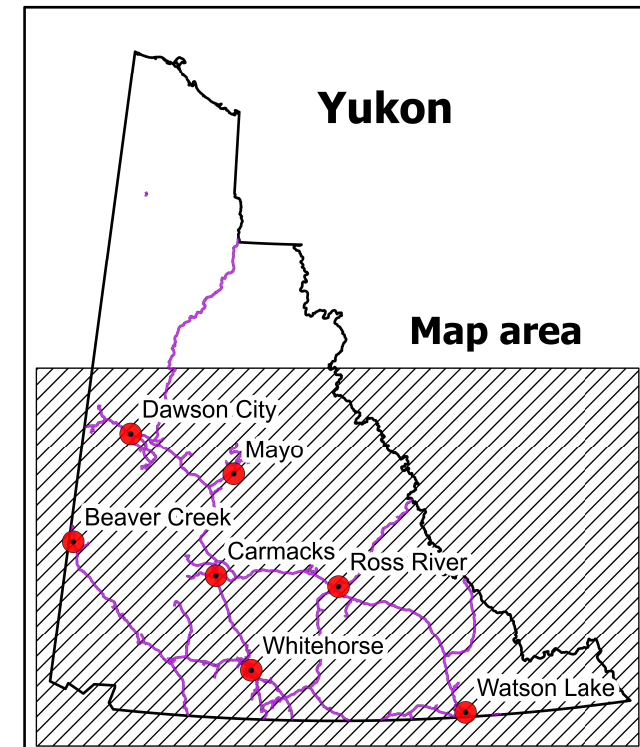
\*A mathematical formula for determining conditional probability, which is the likelihood of an outcome occurring, based on a previous outcome occurring.

**Factors used for porphyry occurrences**

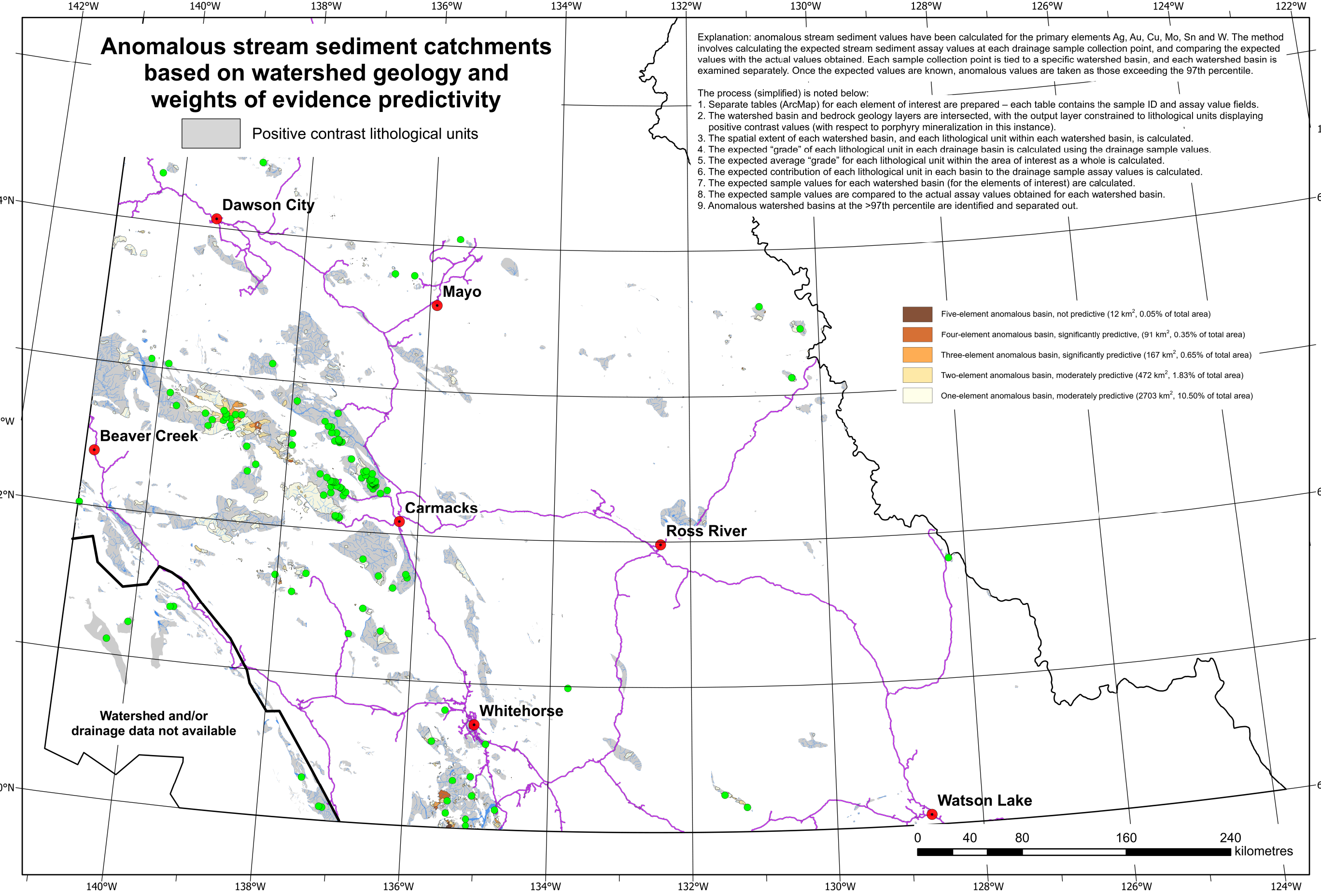
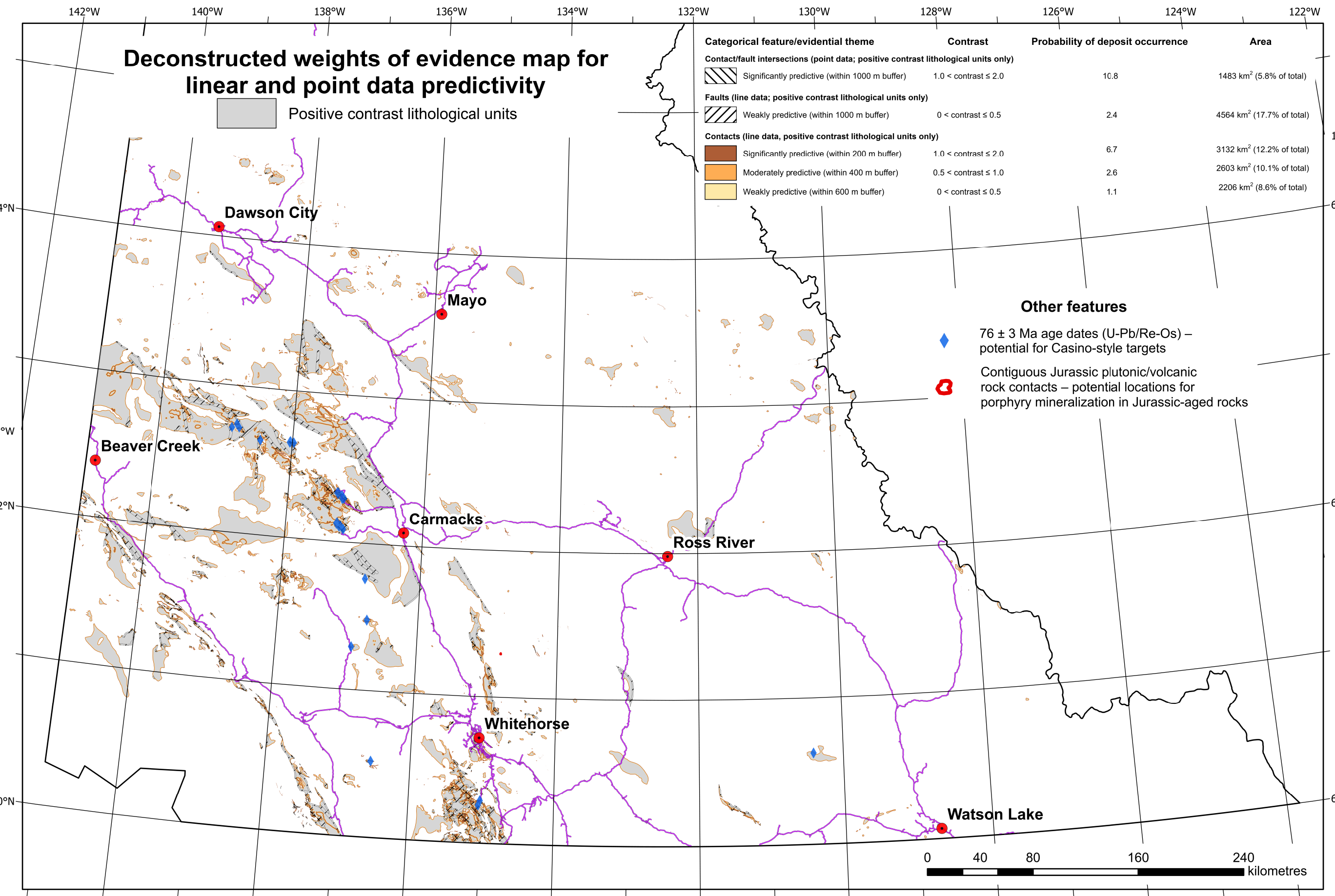
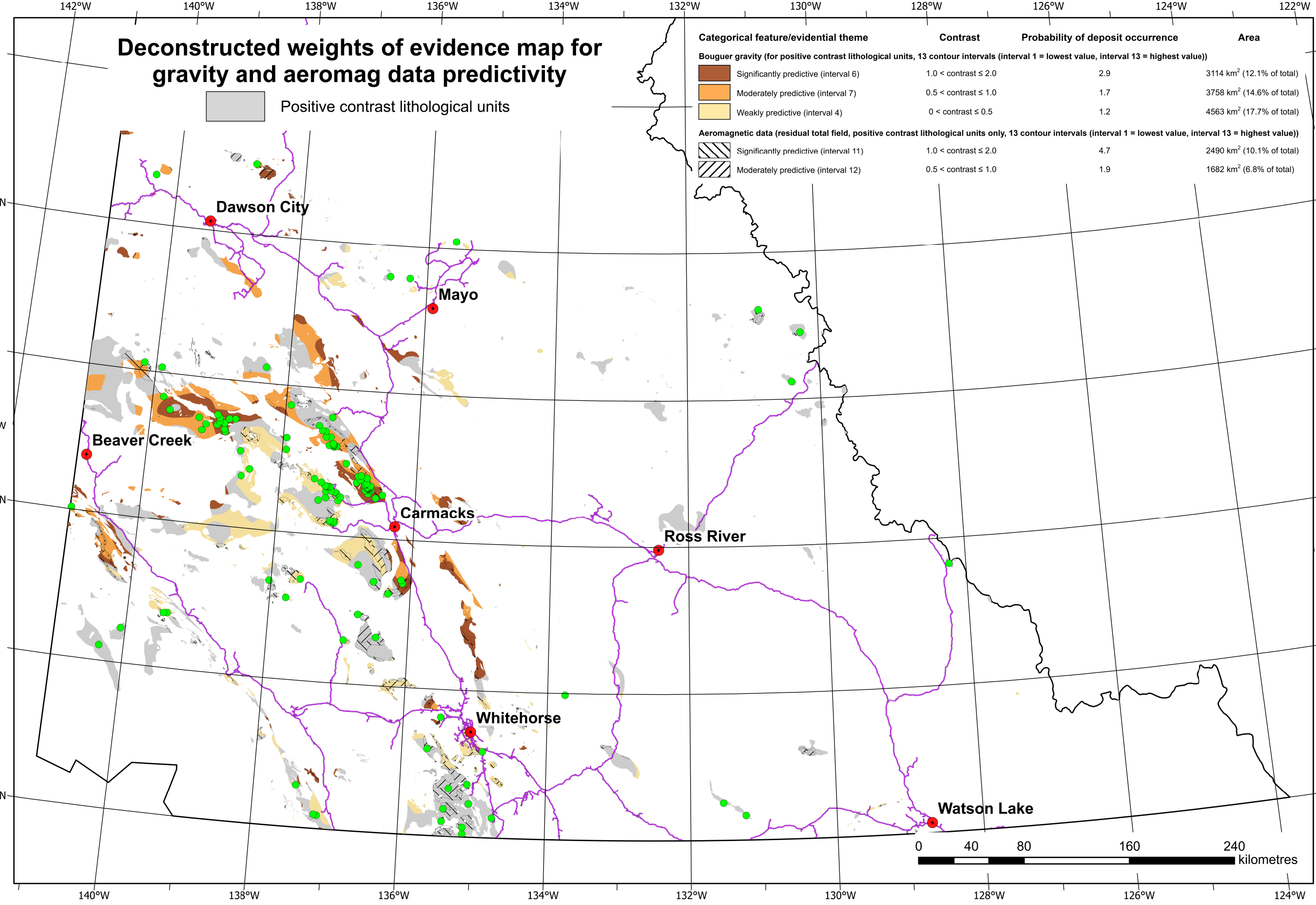
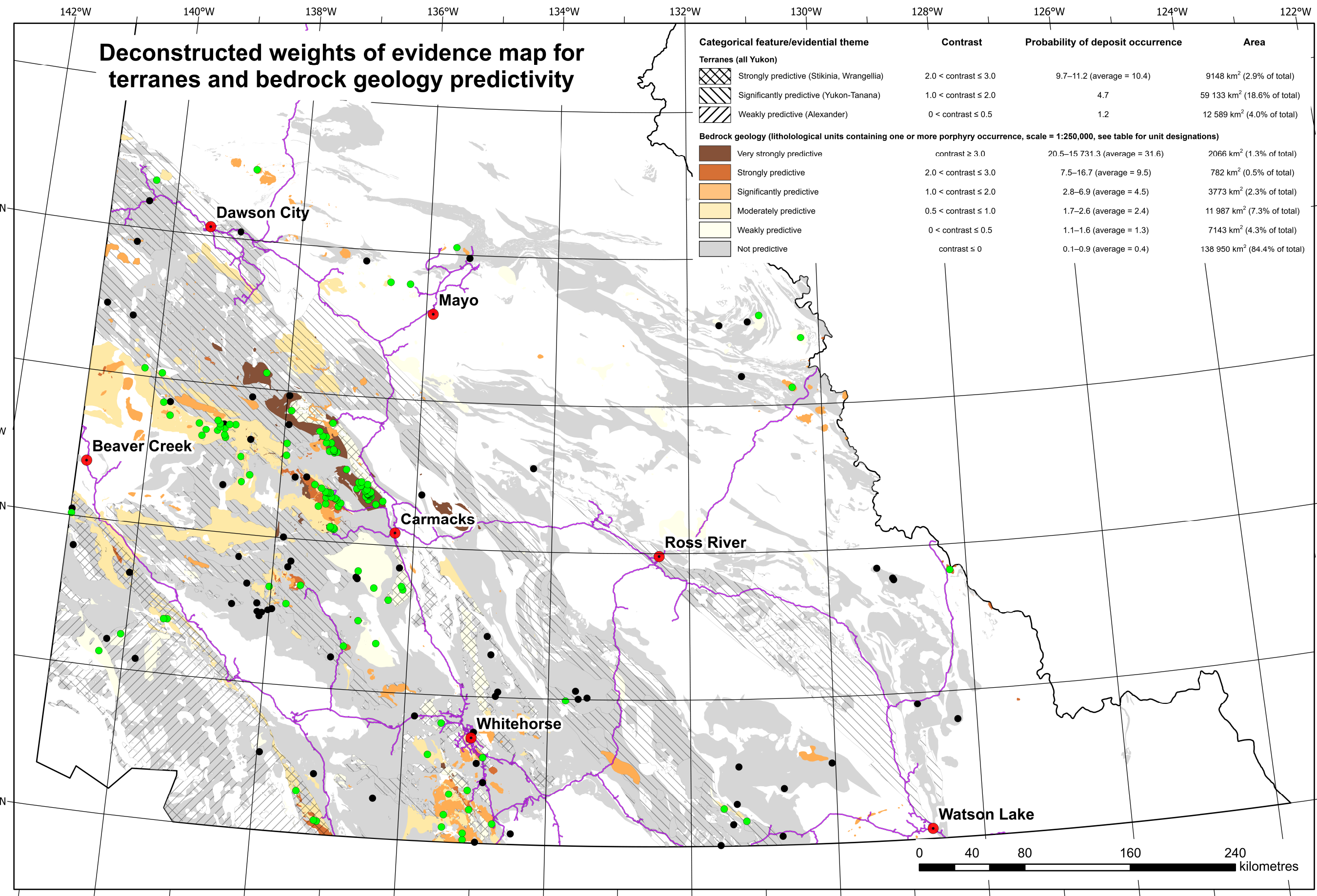
MINFILE	Factor
Producer/past producer	4
Deposit	2
Anomaly/drilled prospect/prospect	1
Showing	0.5
Staked - no work recorded/Unknown	0.2

● Positive contrast porphyry occurrences  
 ● Other porphyry occurrences

**Data sources**  
 Mackie, R.A., Arne, D.C. and Brown, O., 2015. Enhanced interpretation of regional geochemical stream sediment data from Yukon: catchment basin analysis and weighted sums modeling. Yukon Geological Survey, Open File 2015-10, 9 p.  
 Yukon Geological Survey, 2021a. Yukon digital bedrock geology. Yukon Geological Survey, Bedrock Geology data set - Compilation Details - Yukon Geological Survey (gov.yk.ca).  
 Yukon Geological Survey, 2021b. Yukon MINFILE - A database of mineral occurrences. Yukon Geological Survey, https://data.geology.gov.yk.ca/Compilation24 - InfoTab.  
 Yukon Geological Survey, 2021c. Regional geochemical surveys (RGS) - A compilation of Yukon regional stream sediment analysis. Yukon Geological Survey, https://data.geology.gov.yk.ca/Compilation21 - InfoTab.  
 Gravity and aeromagnetic data: http://gdr.aggr.nrcan.gc.ca/gdr/dap/search-eng.php



Maps based on information available as at October 2021.



Lithology unit (Z50K)	No of porphyry records		Contrast
	Actual	Weighted	
uTRPm	5	9	9.69
mkRW	2	3	6.21
LKFC	4	4.5	4.94
LTAS	2	1.5	3.78
LTAgM	32	43.2	3.23
LKP	1	1	3.04
LkVP	1	1	2.84
EVL	4	3.5	2.34
mkGM	1	0.5	2.29
PRC2	1	1	2.16
LKGC	1	1	2.15
LTB	2	1.5	2.04
LkGP	4	3	1.95
LKcC	1	1	1.80
mkGM	2	1.5	1.68
mkW	7	7	1.66
LKqR	1	2	1.55
mkYT	1	1	1.23
TGS	1	1	1.09
EgB	1	1	1.06
PRC1	3	1.7	1.04
CPS2	1	1	0.98
EK	2	2	0.98
mkGM	23	20.5	0.97
LKqM	1	0.5	0.84
mkN	1	1	0.67
PR	1	1	0.66
CFH1	1	1	0.65
PGs	4	4	0.56
uTRP	4	2.5	0.48
mkqM	3	2	0.44
MW	1	1	0.32
EgJL	3	2.5	0.25
CFH2	1	1	0.24
CPD	1	0.5	0.16
mkqTR	1	1	0.15
PDS3	1	0.5	0.11

\*Refer to https://ygsftp.gov.yk.ca/VGISD/compilations/BedrockGeology/OR2016-1\_1\_legend.pdf for lithology names and descriptions.

\*MINFILE records.

Exploration indicator hierarchy (using indicator scores*)		
Subclass	Predictivity	Score
Yukon-Tanana terrane	Significant	3.41
Bedrock geology	Very strong	2.53
Wrangellia/Stikinia terrane	Strong	1.18
Bedrock geology	Moderate	1.10
Contacts	Significant	0.81
Bedrock geology	Significant	0.66
Contact-fault intersections	Significant	0.62
Geophysics - aeromag (rtf)	Significant	0.47
1-element anom. basin	Moderate	0.42
Bedrock geology	Weak	0.37
Geophysics - gravity	Significant	0.35
Bedrock geology	Strong	0.29
Contacts	Moderate	0.26
Geophysics - gravity	Moderate	0.25
Geophysics - gravity	Weak	0.22
Alexander terrane	Weak	0.19
Faults	Weak	0.14
Geophysics - aeromag (rtf)	Moderate	0.13
Contacts	Weak	0.10
3-element anom. basin	Significant	0.06
2-element anom. basin	Moderate	0.06
4-element anom. basin	Significant	0.04
Folds	Not predictive	N/A
Fold/fault contacts	Not predictive	N/A

\*Indicator scores are a function of the probability of a deposit occurring and the area occupied by the subclass of the categorical feature concerned. The score provides a measure of the favourability (attractiveness) of the subclass for exploration - i.e., where the focus should occur initially, immediately thereafter, following on from that, and so on.

This map was built in ArcGIS Pro and exported to a PDF (Portable Document Format) file.

A digital copy of the map may be downloaded free of charge from the Yukon Geological Survey website: https://data.geology.gov.yk.ca

Any revisions or additional geological information known to the user would be welcomed by the Yukon Geological Survey.

Paper copies of this map may be obtained from Yukon Geological Survey, Room 102 - 300 Main St., Whitehorse, Yukon, Y1A 2B5. E-mail: geology@gov.yk.ca