2.3 GROWING DEGREE DAYS

The growing degree day or heat unit concept was originally suggested by Reaumur over 200 years ago (Holmes and Robertson, 1959). The degree day theory assumes that plant growth commences at a particular base temperature. It has been determined, for grapes, that growth begins at a mean temperature of 10°C. The accumulation of growing degree days throughout the growing season above the 10°C base temperature permits the assessment of grape growing potential in a region.

The method of calculating growing degree days is quite simple. The growing season, during which degree days are accumulated, must first be specified. The date in spring when degree days begin to be accumulated is defined as the first day of 5 consecutive days with a mean temperature above 10°C. Similarly, the end of the growing season in autumn occurs when there is no longer five consecutive days with a mean temperature above 10°C. The number of degrees (°C) that the mean temperature is above 10° C is accumulated for each day from the first to last day of the growing season. For example, if on a particular day the mean daily temperature is 25°C, the number of growing degree days accumulated to the seasonal total is 15 (e.g. 25-10 = 15).

The growing of most varieties of grapes requires a large accumulation of growing degree days to permit the fruit to ripen. Insufficient degree days will not permit wine grapes to attain the required sugar content. The more heat demanding vinifera and French hybrid grape varieties are most particular in their heat unit requirements. Winkler (1974), in his work with French and German wine grapes in California, found that an accumulation of 1390 degree days was the optimum required. In the German Rhine area, 944 was identified as the lowest accumulated degree day total acceptable for commercial wine grape production. Similarly, Prescott (1965) observed that in Australia heat unit totals should be at least 890 to 1000.

Four growing degree day suitability classes, shown below, were derived based upon the response of vinifera and French hybrid varieties grown in the Okanagan and Similkameen Valleys.

Class	Degree Days	Rating
1	1390 and above	Most suitable
2	1165 to 1389	Good suitability
3	945 to 1164	Fair suitability
4	Less than 945	Questionable suitability

2.3.1 Effect of Growing Degree Days on Grape Quality

The use of the growing degree day concept provides information as to the varieties of grapes that can be grown and the quality of wine that can be produced. Vineyards in Class 4, on average, will experience a short growing season with low temperatures. Very early maturing varieties only, will succeed in this area and acid content may be high unless low acid varieties are grown. Table wines produced from high acid/low sugar grapes will be low in alcohol and dry, as well as tart.

Grapes grown in a Class 1 area will have the longest growing season. Table wines produced from these grapes will have a higher alcohol content and will be somewhat sweeter and more mellow than wine from grapes grown in less suitable areas. The same variety, when grown in the Class 2 region, will generally have a higher acid content than if it had been grown in the Class 1 area. In many cases, the grapes grown in the cooler Class 2 regions will develop more flavour than similar varieties grown in a Class 1 region.

The degree day concept is not without some problems. There is no accounting for a lessening in a plant's growth response at temperatures above about 27°C. Also, no allowance is made for a change in the temperature threshold or the effect of the range between maximum and minimum temperature as a crop develops. Finally, degree day accumulations do not permit the differentiation between the combination of a warm spring and cool summer, and the combination of a cool spring and a warm summer (Chang, 1963).

Despite these drawbacks, the growing degree day method remains an effective, understandable, and readily comparative concept in guiding the grape growing industry throughout the world.

2.3.2 Growing Degree Days in the Okanagan and Similkameen Valleys

A large number of climate stations throughout the Okanagan and Similkameen Valleys have been used in determining and mapping the growing degree day climate. Average degree day figures were calculated for longer term climate stations directly, while the short-term station, with less than 15 years of data, required that long-term averages be estimated. These estimates were calculated by comparing short-term station data to a nearby long-term base station.

To enable an analysis of the growing degree day climate, the large study area was divided into three smaller but more climatically similar subregions. The first subregion, the Similkameen Valley, was identified because it is geographically separate from the Okanagan Valley. Conversely, the Okanagan Valley has been divided into two subregions on the basis of climatic factors. A significant but gradual change in climate occurs from south to north in this valley. More precipitation, cooler temperatures and lower sunshine amounts are evident the further north one proceeds. The most significant change in the climatic region occurs in the Okanagan Falls area. The growing degree day subregions are as follows:

1. Similkameen Valley;
2. Okanagan Valley north from the U.S. Border to Okanagan Falls; and,
3. Okanagan Valley from Okanagan Falls north to Okanagan Centre.

Linear regressions of growing degree days versus the elevation above valley bottom were developed for each of the three subregions. In the Similkameen valley, no mapping was done beyond 40 meters (130 ft) above the valley floor, because of a lack of climatic data.

In the Okanagan Valley, a general increase in growing degree days occurs to about 100 meters (330 ft) above valley bottom. Below this elevation, the number of growing degree days is affected by the cooler temperatures occuring near valley bottom, a result of cool air pooling. Minimum temperatures increase rapidly above the valley floor to about 100 meters (330 ft). A lowering of both minimum and maximum temperatures above 100 meters (330 ft) results in a gradual reduction of growing degree day accumulations. These processes are shown diagrammatically in Figure 4.

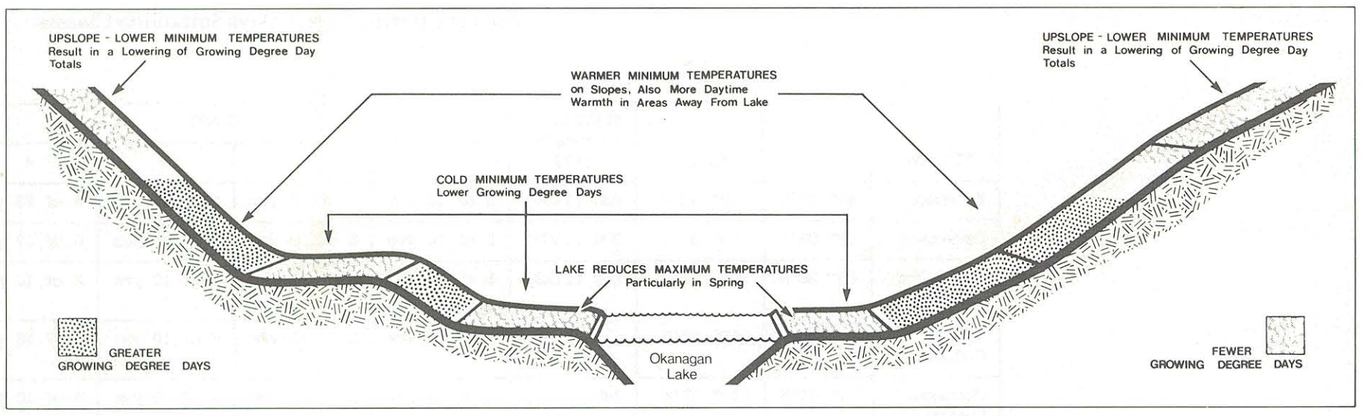


Figure 4 The Effect of Topography and Proximity to Large Lakes on Growing Degree Day Accumulation

2.3.3 Growing Degree Days Patterns

The Similkameen Valley has a warm growing season climate. The number of growing degree days attained is very similar to degree days accumulated throughout the warmest areas of the south Okanagan. This is a result of mild nights and warm days which are experienced throughout the growing season. At night, conditions which normally would be expected to be clear, calm and cool are instead often windy and moderately warm.

Southwesterly slopes experience the highest temperatures resulting in a Class 1 climate with more than 1390 growing degree days. The cooler valley bottoms have a Class 2 growing degree day climate, with the exception of the south end of the subregion where Class 1 is found.

The area from Keremeos west to the Ashnola Valley is cool primarily because of topographic shading and reduced incoming solar radiation. This results in a slight lowering of the growing degree day accumulation to Class 2. Richter Pass, in the vicinity of Frank to Richter lakes, has much cooler maximum and minimum temperatures and, therefore, reaches only a Class 3 growing degree day climate.

Many factors affect heat unit accumulations in the south Okanagan. Away from the moderating affect of the larger lakes valley bottom locations are prone to cold air pooling at night. This cold air pooling lowers heat unit accumulations of the low lying areas resulting in a Class 2 growing degree day climate. Upslope large areas of Class 1 climate extend from just south of Oliver to the U.S. Border on the east side of the valley. There also is some Class 1 on the west side of the valley in the vicinity of Osoyoos Lake and Oliver. Further upslope, the accumulated heat units quickly fall through Class 2 to Class 3. A large area of Class 2 also is located in the Inkameep Creek Valley.

North of Oliver, the Class 2 growing degree day climate extends through most of the valley, except for a narrow band of Class 1 on the east side of the Okanagan River from Tugulnuit Lake to just north of Vaseaux Lake. A substantial block of Class 1 exists on the west side of Skaha Lake near Kaleden and east side south of Gilles Creek to Okanagan Falls. Higher and colder side valley regions, such as Park Rill Creek near Oliver, experience a Class 3 growing degree day climate.

In response to the moderating affects of Okanagan Lake, the central Okanagan growing season climate is slightly cooler than throughout the south Okanagan. During the spring and early summer, the area adjacent to the lake is noticeably cooled by air originating over Okanagan Lake. As a result, the number of degree days accumulated is reduced, and there is an absence of Class 1 growing degree day climate.

Class 2 growing degree day climate exists on the south aspect of Mt. Boucherie and in a very narrow band from Peachland to Mt. Boucherie. A slightly larger area of Class 2 exists from the north end of Skaha Lake to north of Summerland. The east side of Okanagan Lake has a narrow band of Class 2 climate from the north end of Skaha Lake to Squally Point. Above these narrow strips of Class 2, extending north to Westbank on the west side of the lake and north to Squally Point on the east side is an area of Class 3. North of Squally Point to Okanagan Mission, a less favourable northwesterly aspect results in the absence of Class 1 and 2 climates.

There is also a somewhat larger area of Class 2 growing degree day climate on the front benches of East Kelowna in response to the warm night air above the valley bottom. Maximum temperatures are higher

during the day because of favourable east and west aspects, and the increased distance from the cooling influence of Okanagan Lake.

North of Kelowna, in the vicinity of Okanagan Centre, the majority of the area is a Class 3 climate. Large low lying areas south of Winfield are within the Class 4 climate. Kelowna Airport is representative of these low lying sites and is very prone to cold air pooling with a resultant decrease in growing degree days.

2.3.4 The Affects of Microclimate Upon Growing Degree Day Accumulations

It must be stressed that the climate mapping has been based upon data from climate stations in the Okanagan and Similkameen Valleys. Because of microclimatic differences, there are sites that have better or worse climates than the mapping contained herewith indicates. Small heat pockets on south facing slopes, for example, will result in more heat units accumulated. This may improve such localities to a more favoured class. Conversely, poorly exposed low lying areas subjected to cold air drainage, may have lower classifications than those shown on the map.

2.3.5 The Frequency of Occurrences of Growing Degree Day Suitability Classes

It is important to consider the frequency of occurrence of growing degree day suitability classes in addition to the average values mapped. Table 15 provides some of these frequencies for five major climate stations throughout the region.

Keremeos, in the Similkameen Valley, has reached at least a Class 3 growing degree day climate in more than eight out of ten years, a Class 2 rating in more than five out of ten years and a Class 1 in more than two out of ten years. Keremeos has not experienced a growing season with a Class 4 growing degree day climate in twenty-two years of record. The Similkameen Valley in the vicinity of Keremeos has a growing degree day climate similar to that experience in the southern Okanagan Valley.

The Osoyoos station (typical of many lower elevation sites in the south) experiences growing degree day accumulations that reach a Class 3 or better in nine out of ten years. A Class 2 or better climate is experienced in eight out of ten years and a Class 1 rating occurs in more than two out of ten years. The Osoyoos station has never experienced a Class 4 growing degree day suitability rating during the seventeen years of record.

Penticton Airport is a site representative of valley bottom locations in the south central portion of the Okanagan Valley. Here, a Class 3 or better climate occurs in eight out of ten years, a Class 2 or better climate in one out of ten years and a Class 1 rating has occurred only once in thirty-nine years.

Summerland C.D.A., a site typical of warmer upslope locations in the south central Okanagan, has a much more advantageous growing degree day climate for grapes than does Penticton Airport. This is not only expressed in the growing degree day averages, but is also reflected in the frequency analysis. A Class 2 is reached in more than five years out of ten compared to one year in ten at Penticton Airport. Also, the best growing degree day climate rating (Class 1) has occurred four years in sixty-four at Summerland C.D.A.

There currently is an absence of operating long term climate stations in the Kelowna area and as a result, the northern portion of the study area has been represented by Okanagan Centre. This station displays a Class 3 climate or better in eight out of ten years, while a Class 2 may be expected more than two times in ten years. This is better than Penticton Airport's growing degree day climate, but not as good as Summerland's figures. Okanagan Centre, in forty-three years of record, has not observed a Class 1 suitability rating.

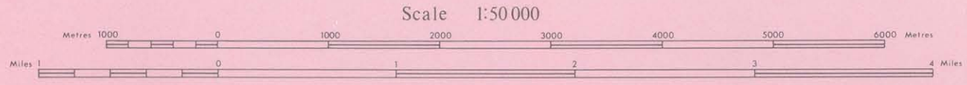
Table 15
Frequency of Growing Degree Days Suitability Classes

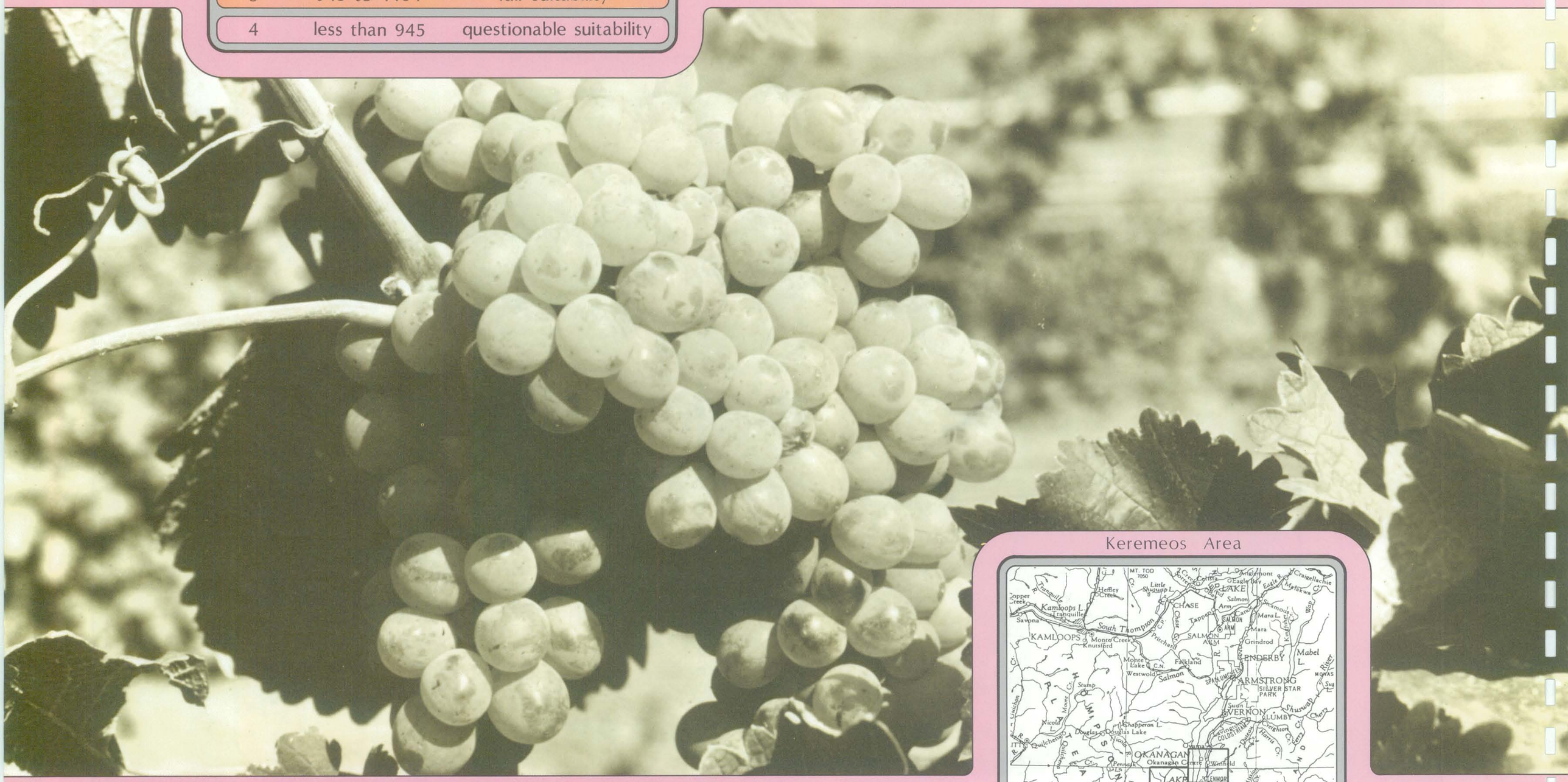
STATION	LATITUDE	LONGTITUDE	ELEVATION in meters (ft)	CLASS				AVERAGE (5 of 10 yrs)		PERIOD OF RECORD
				1	2	3	4	DEGREE DAYS	CLASS	
Keremeos	49° 12'N	119° 47'W	430 (1410)	2 of 10 yrs	5 of 10 yrs	8 of 10 yrs	0 of 22 yrs	1336	2	22 Years
Osoyoos	49° 03'N	119° 31'W	326 (1069)	2 of 10 yrs	8 of 10 yrs	9 of 10 yrs	0 of 17 yrs	1359	2	17 Years
Penticton Airport	49° 28'N	119° 36'W	342 (1122)	1 of 39 yrs	1 of 10 yrs	8 of 10 yrs	9 of 10 yrs	1071	3	39 Years
Summerland C.D.A.	49° 34'N	119° 39'W	455 (1492)	1 of 16 yrs	5 of 10 yrs	9 of 10 yrs	1 of 16 yrs	1172	2	64 Years
Okanagan Centre	50° 04'N	119° 27'W	348 (1141)	0 of 43 yrs	2 of 10 yrs	8 of 10 yrs	9 of 10 yrs	1049	3	43 Years

Example: Osoyoos reaches a Class 3 suitability or better in 9 out of 10 yrs, a Class 2 or better in 8 out of 10 yrs and a Class 1 in more than 2 out of 10 yrs. Class 4 has not occurred during the period of record. The average value (5 out of 10 yrs), Class 2, was used for mapping purposes.

Class	Degree Days	Rating
1	1390 and above	most suitable
2	1165 to 1389	good suitability
3	945 to 1164	fair suitability
4	less than 945	questionable suitability

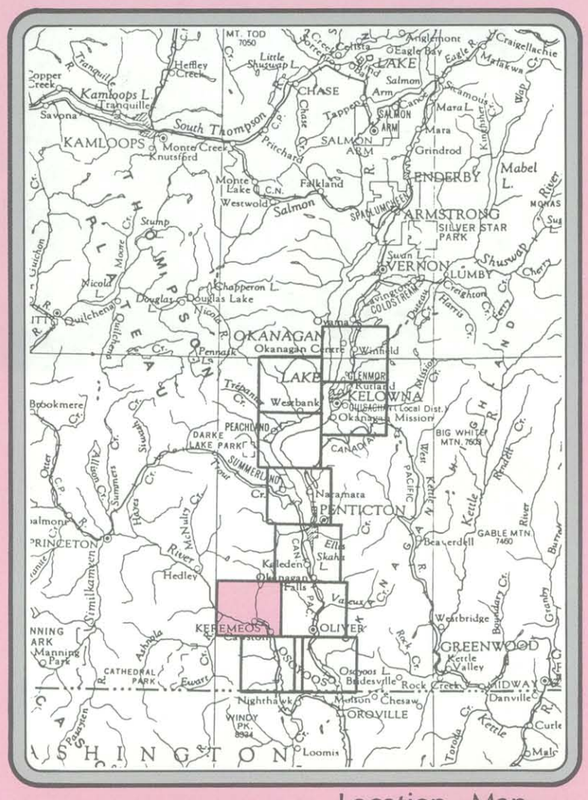
Scale 1:50 000



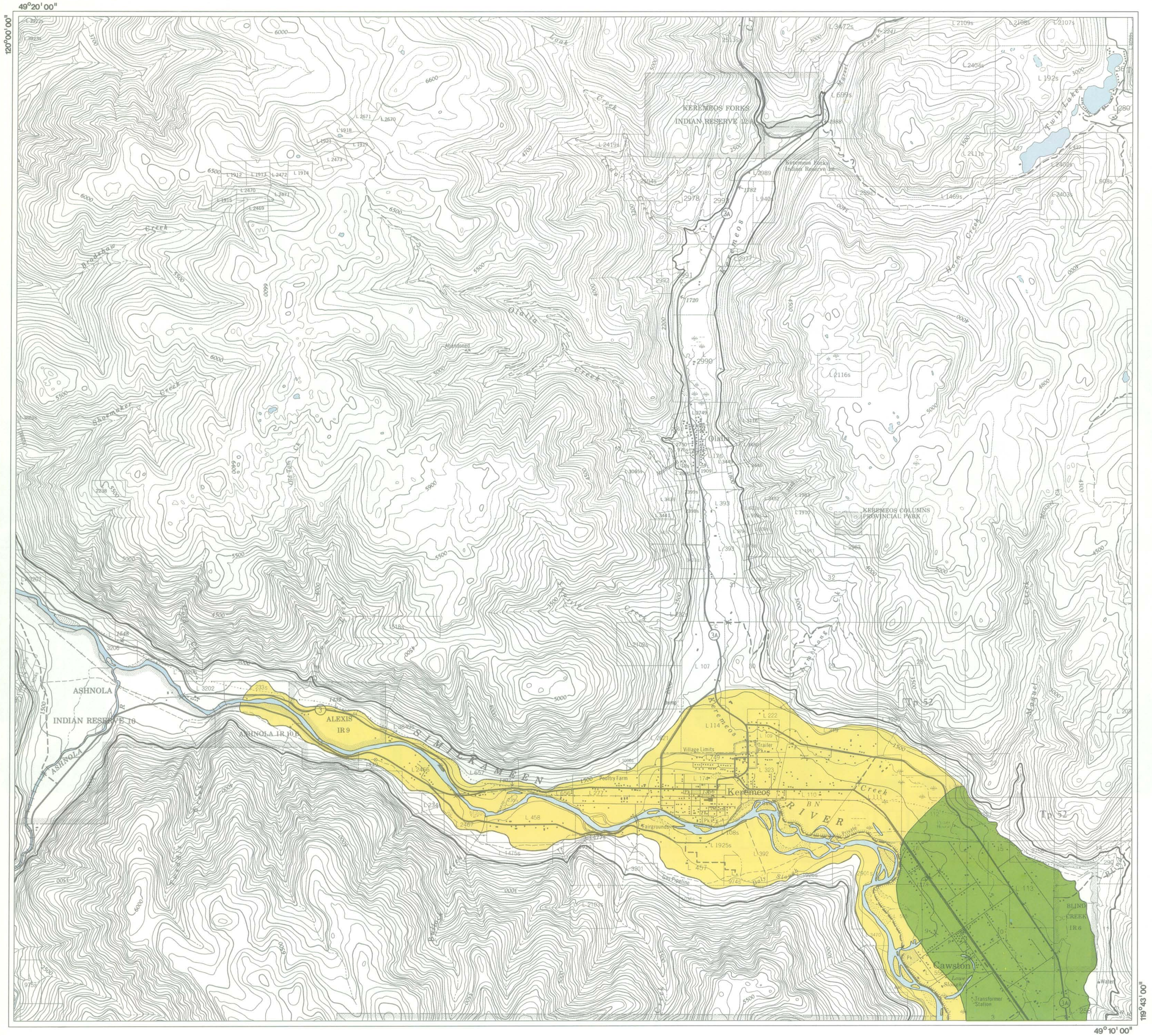


GROWING DEGREE DAYS

Keremeos Area



Location Map


49°20'00"
120°00'00"
KEREMEOS FORKS
INDIAN RESERVE 12
Keremeos Forks Indian Reserve 12
Olalla
KEREMEOS COLUMNS
PROVINCIAL PARK
ASHNOLA
INDIAN RESERVE 10
ASHNOLA IR 10A
ALEXIS
IR 9
SIMILKAMEEN
RIVER
Keremeos
Village Limits
Poultry Farm
Fairgrounds
Cawston
BLIND
CREEK
IR 6
Transformer Station
Tp 52
Creek
49°10'00"
119°43'00"

49°10'00"

119°52'00"

ASHNOLA

INDIAN RESERVE 13

PROVINCIAL

FOREST

NARCISSE'S FARM

LOWER SIMILKAMEEN IR 2

SIMILKAMEEN

BURLINGTON NORTHERN

OKANAGAN

PROVINCIAL

FOREST

Mount Kobau

Golf Course

Television

Radio-TV Observatory

SKEMEOSKUANKIN INDIAN RESERVE 8

SKEMEOSKUANKIN INDIAN RESERVE 7

RIVER

RICHTER MOUNTAIN

Richter L.

Frank L.

OKANAGAN PROVINCIAL FOREST

Chopaka

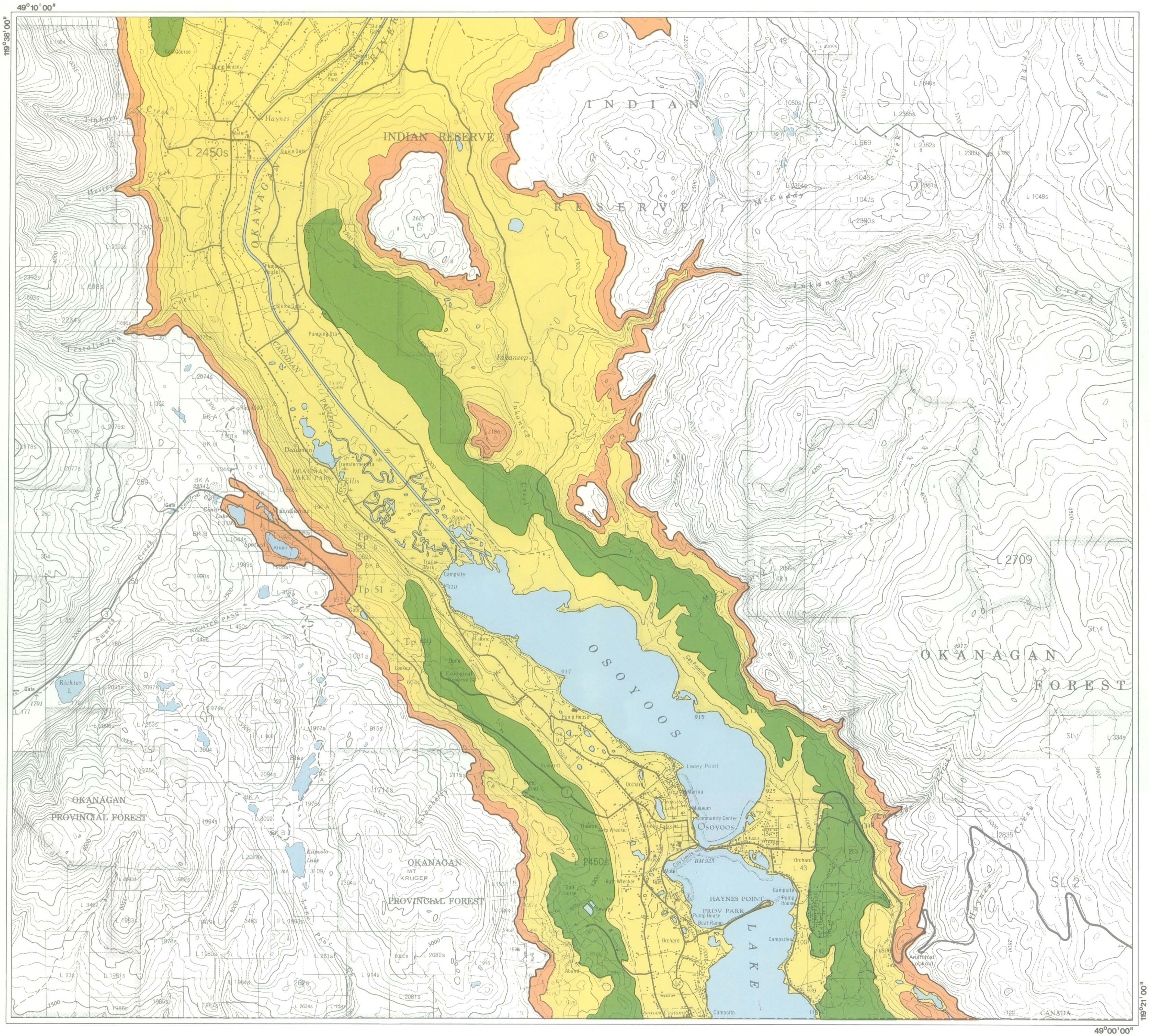
Chopaka Customs

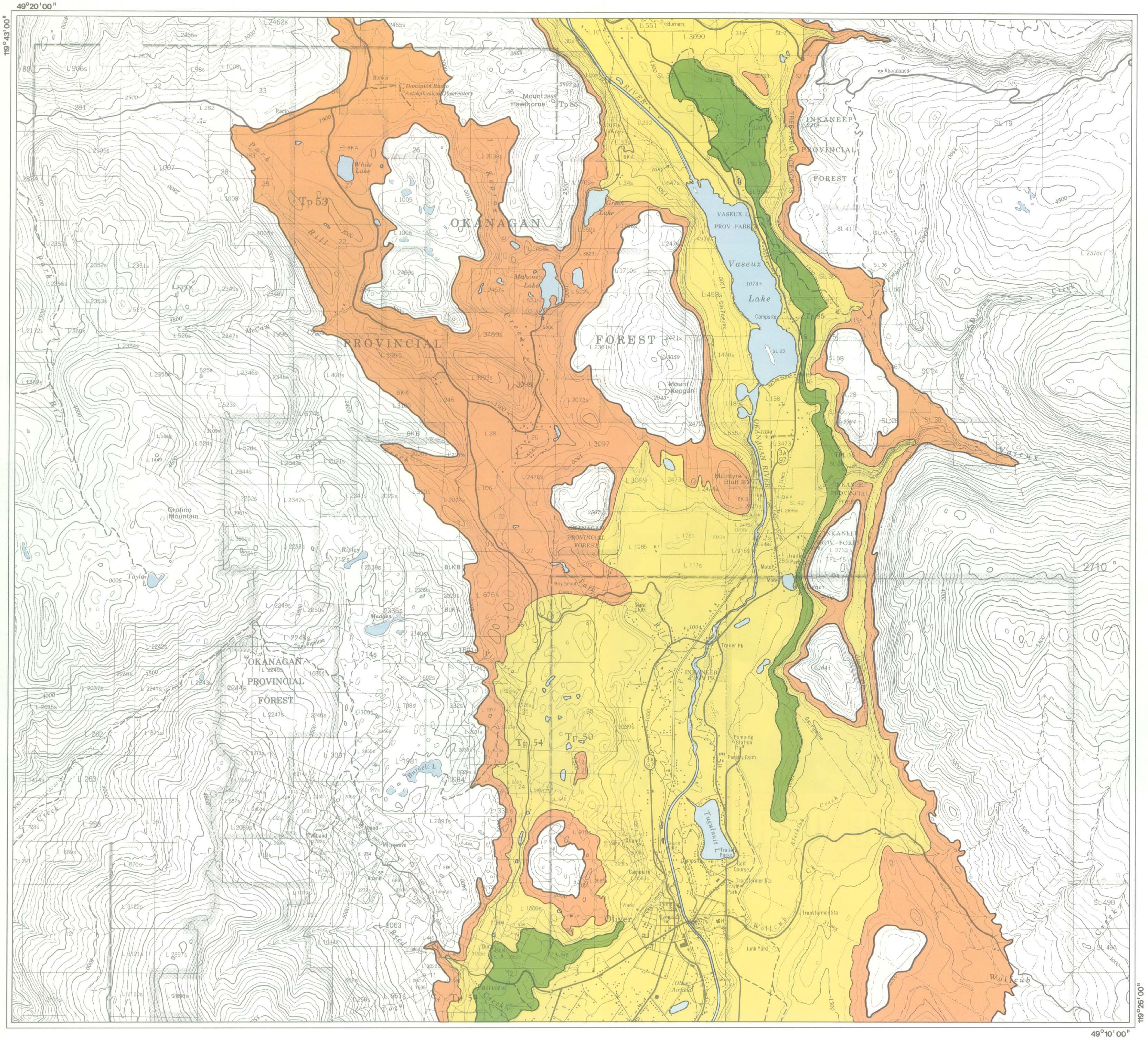
CANADA

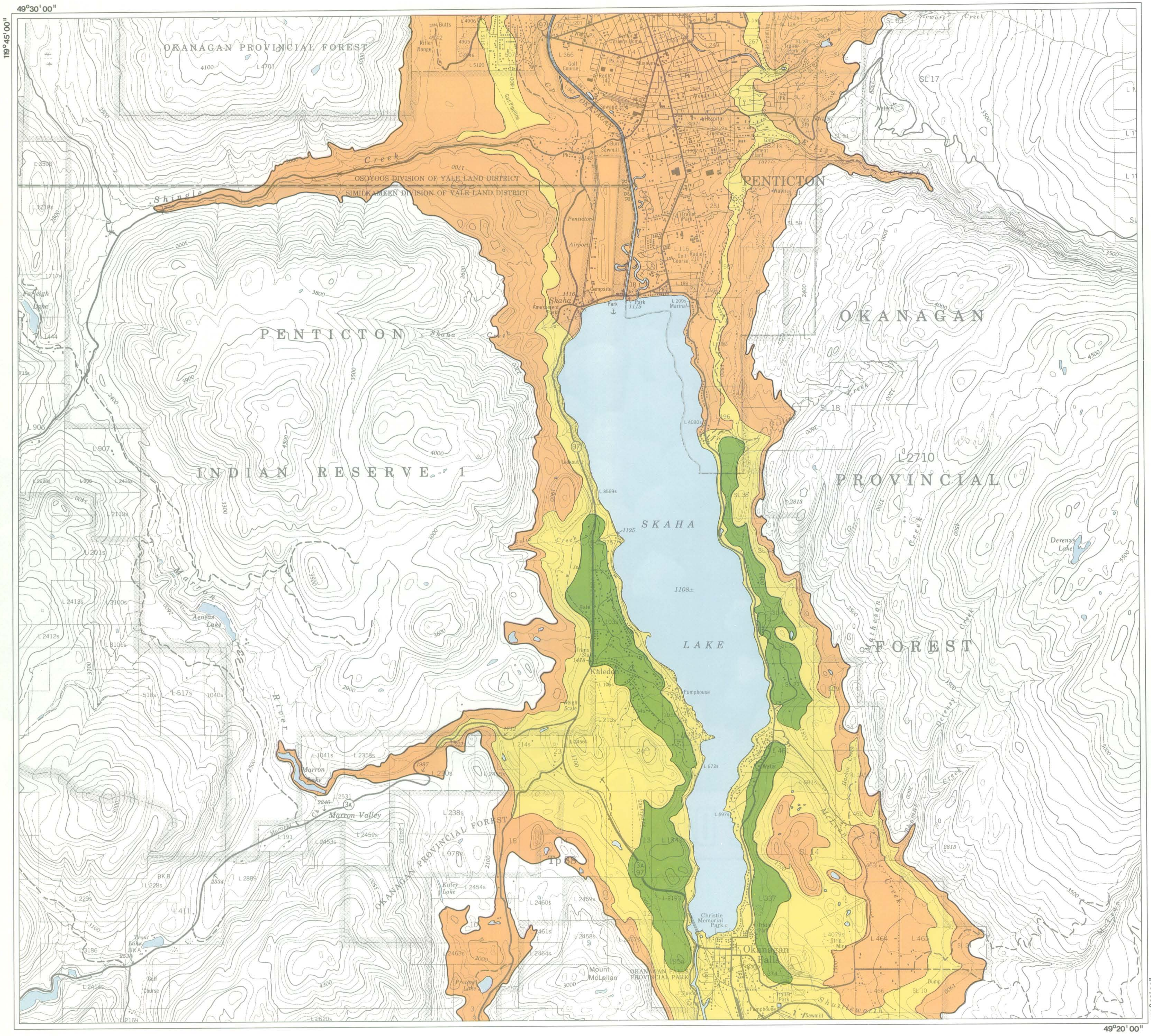
BRITISH COLUMBIA

49°00'00"

119°35'00"


49°10'00"
119°38'00"
INDIAN RESERVE 1
INDIAN
RESERVE 1
OKANAGAN RIVER
CANADIAN PACIFIC
Haynes
L 2450s
Inkaneep Creek
Testalinden Creek
Hester Creek
Tinhorn Creek
McCuddy Creek
Deadman Lake
DEADMAN LAKE PARK
Ellis
Kennedy Lake
Mahoney Lake
Spotted Lake
Alkali Lake
Tp 51
Tp 49
RICHTER PASS
Richter L
Blue Lake
Kilpoola Lake
Strawberry Creek
Kruger Lake
Blue Lake
OKANAGAN PROVINCIAL FOREST
OKANAGAN
MT KRUGER
PROVINCIAL FOREST
OSOYOOS
LAKE
Lacey Point
Osoyoos
Marina
Community Center
HAYNES POINT PROV PARK
City Limits
L 2709
OKANAGAN
FOREST
Haynes Creek
L 2835
SL 2
CANADA
Anarchist Lookout
49°00'00"
119°21'00"

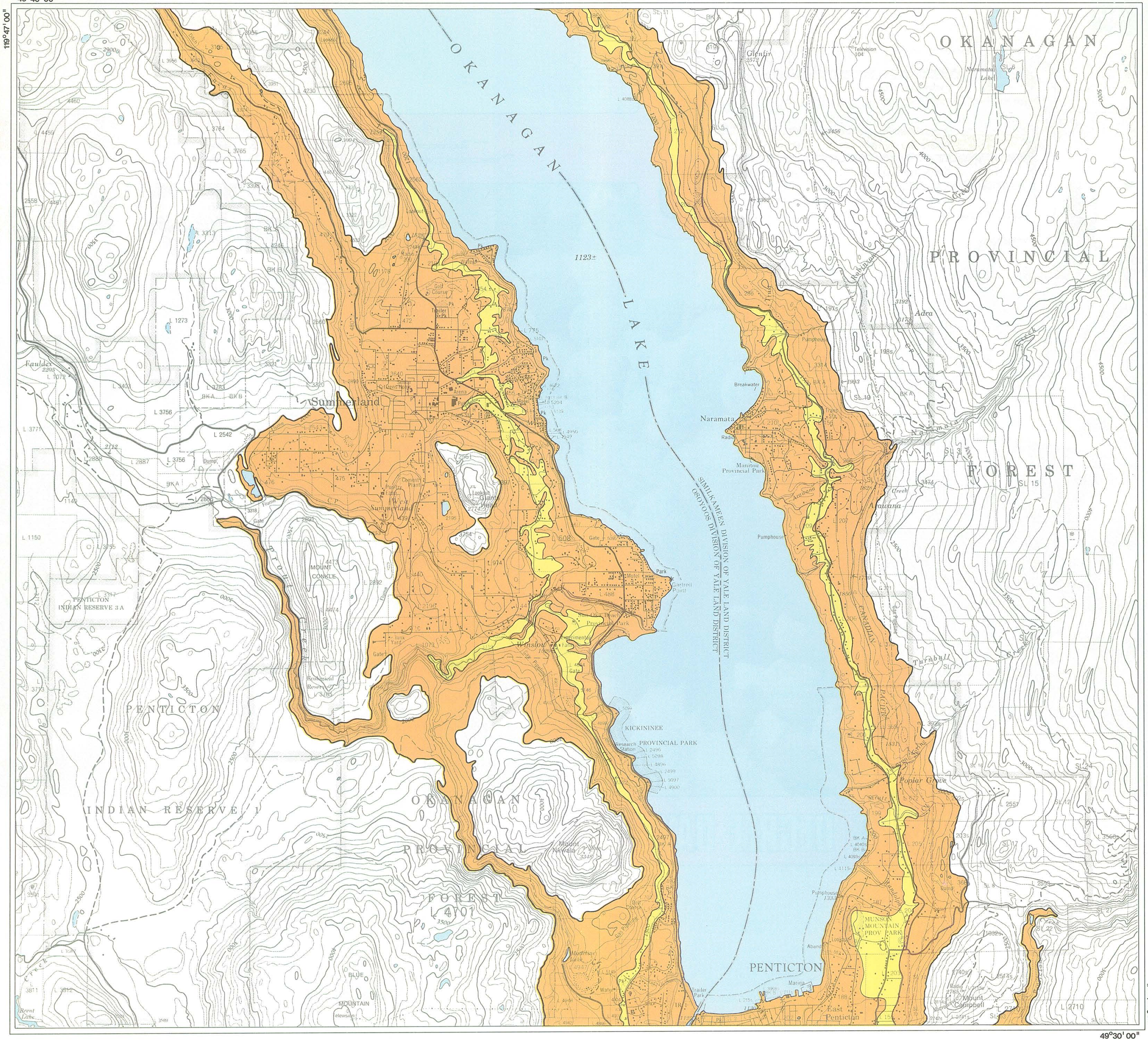

49°20'00"
119°43'00"
119°26'00"
49°10'00"
OKANAGAN
PROVINCIAL
FOREST
Tp 53
Tp 85
Tp 54
Tp 50
Park Rill
White Lake
Dominion Radio Astrophysical Observatory
Mount Hawthorne
Green Lake
Mahoney Lake
Mount Keogan
McIntyre Bluff
Vaseux Lake
VASEUX L PROV PARK
Campsite
OKANAGAN RIVER
INKANEEP PROVINCIAL FOREST
Vaseux Creek
Orofino Mountain
Taylor
Ripley
Madden
Burnell L
Tugulnuit L
Oliver
Oliver Airfield
Fairview
Wolfcub Creek
Reed Creek
Gallagher
Pumping Station
Poultry Farm
Golf Course
Trailer Parks
Transformer Sta
Junk Yard
2710



49°30'00"
119°45'00"
OKANAGAN PROVINCIAL FOREST
OSOYOOS DIVISION OF YALE LAND DISTRICT
SIMILKAMEEN DIVISION OF YALE LAND DISTRICT
Shingle Creek
Ellis Creek
PENTICTON
PENTICTON INDIAN RESERVE 1
OKANAGAN PROVINCIAL FOREST
SKAHA LAKE
Farleigh Lake
Aeneas Lake
Marron River
Marron Lake
Marron Valley
OKANAGAN PROVINCIAL FOREST
Kaleden
Pomphouse
Matheson Creek
Derenzy Lake
McLean Creek
Christie Memorial Park
Okanagan Falls
OKANAGAN FALLS PROVINCIAL PARK
Mount McLellan
Shuttleworth Creek
119°28'00"
49°20'00"

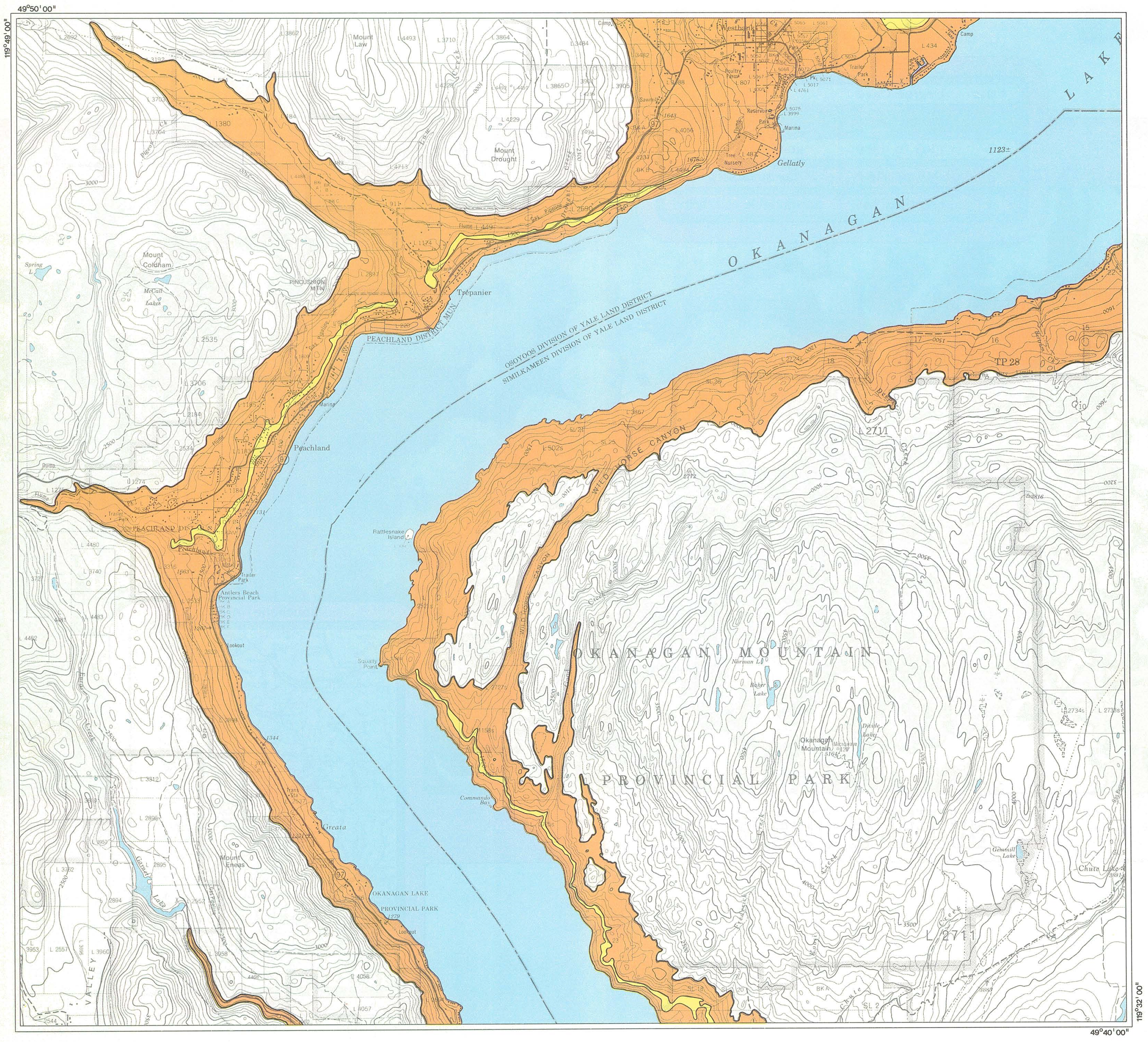
49°40'00"

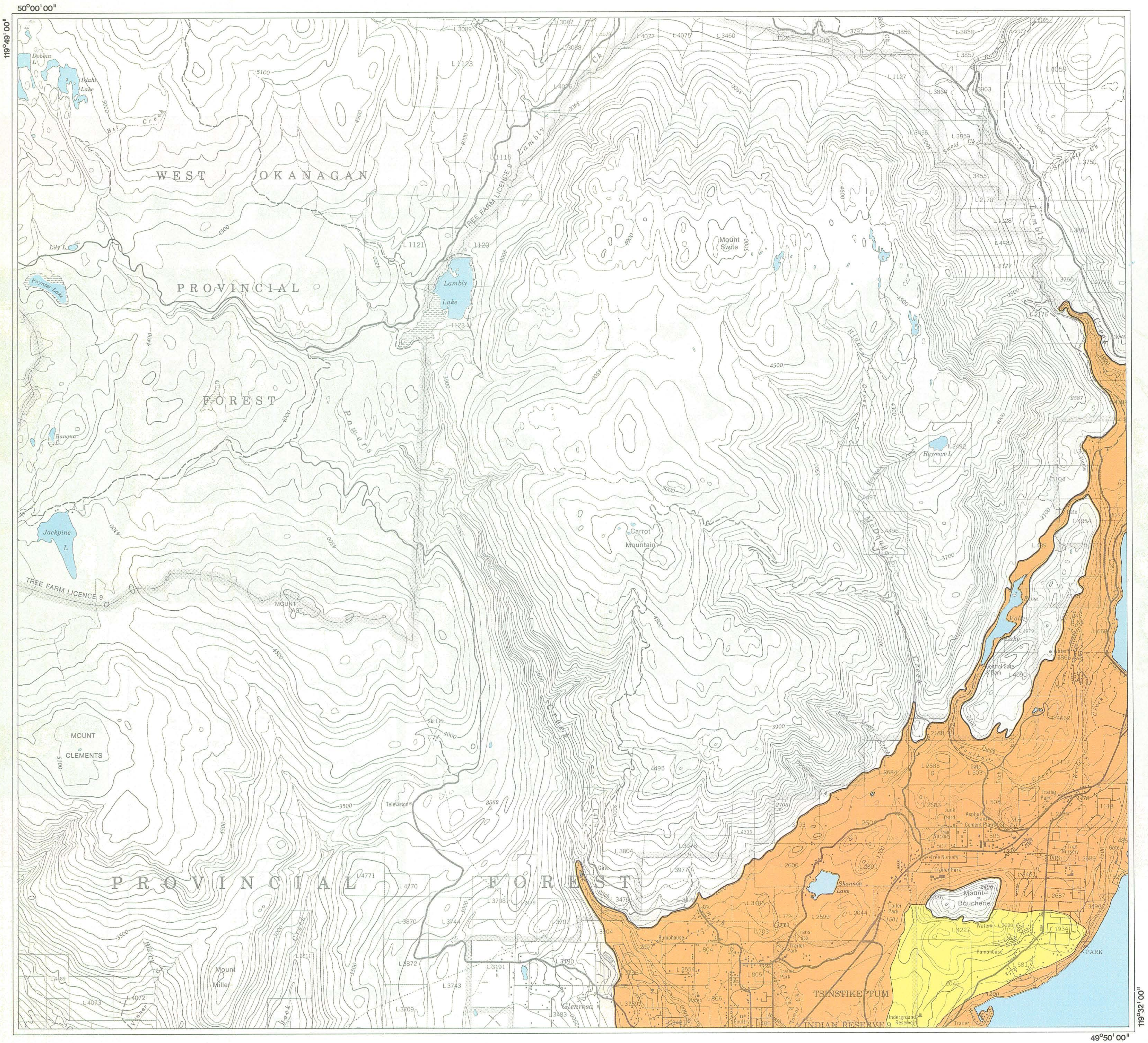
119°47'00"

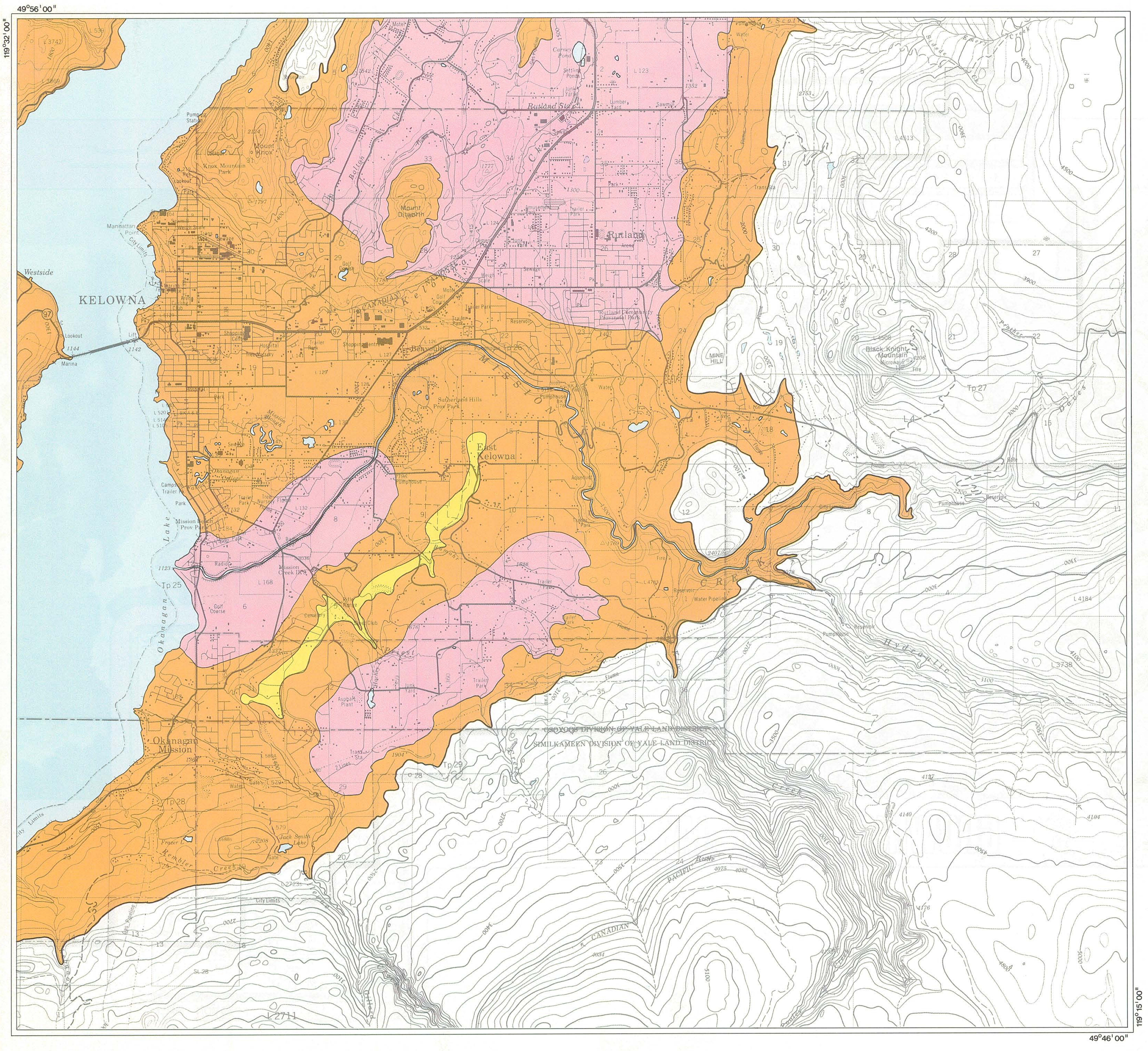


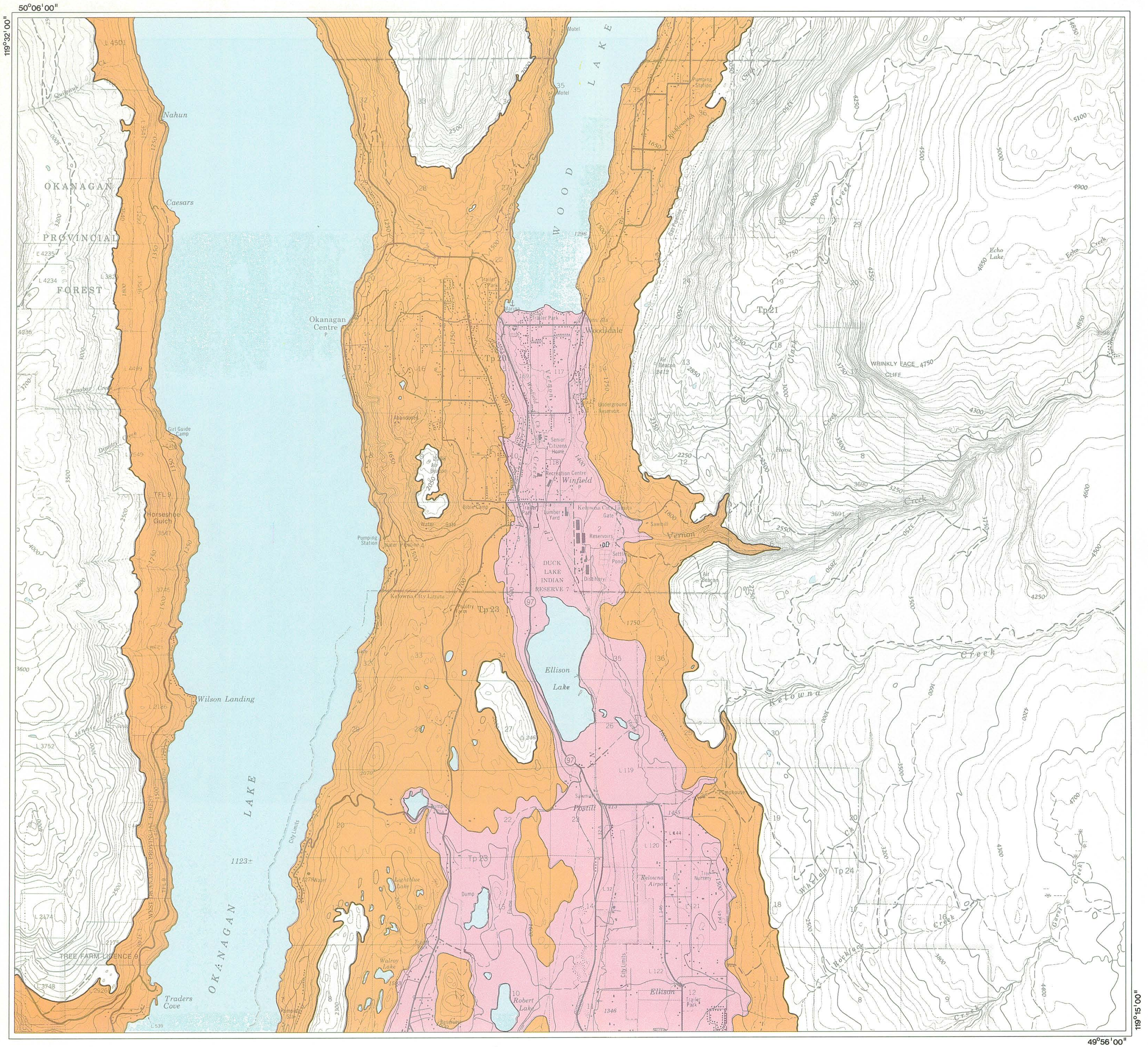
119°30'00"

49°30'00"


49°50'00"
119°49'00"
119°32'00"
49°40'00"
OKANAGAN LAKE
1123±
OSOYOOS DIVISION OF YALE LAND DISTRICT
SIMILKAMEEN DIVISION OF YALE LAND DISTRICT
PEACHLAND DISTRICT MUN.
Westbank
Gellatly
Marina
Trepanier
Peachland
Pincushion Mtn
Mount Law
Mount Drought
Mount Coldham
McCall Lake
Spring L.
Rattlesnake Island
Antlers Beach Provincial Park
Lookout
Squally Point
Commando Bay
Greata
Mount Eneas
Garnet Lake
OKANAGAN LAKE PROVINCIAL PARK
WILD HORSE CANYON
OKANAGAN MOUNTAIN PROVINCIAL PARK
Norman L.
Baker Lake
Divide Lake
Okanagan Mountain
Gemmill Lake
Chute Lake
VALLEY
TP 28
L 2711


50°00'00"
119°49'00"
119°32'00"
49°50'00"
WEST OKANAGAN
PROVINCIAL
FOREST
PROVINCIAL FOREST
TREE FARM LICENCE 9
Lambly Lake
Mount Swite
Carrot Mountain
MOUNT LAST
MOUNT CLEMENTS
Mount Miller
Mount Boucherie
Jackpine L
Paynter Lake
Lily L.
Banana L.
Dobbin L.
Islaht Lake
Shannon Lake
Rosman L.
Lambly Ck
Powers
McDougall Creek
Bit Creek
Glenrosa
TSINSTIKEPTUM
INDIAN RESERVE 9
PARK
Ski Lift
Television
Pumphouse
Trailer Park
Tree Nursery
Asphalt Plant
Cement Plant
Underground Reservoir


49°56'00"
119°32'00"
KELOWNA
Westside
Mount Knox
Knox Mountain Park
Manhattan Point
City Limits
Mount Dilworth
Rutland
Rutland Sta
Black Knight Mountain
MINE HILL
East Kelowna
MISSION
CREEK
Mission Creek Prov Park
Sutherland Hills Prov Park
Okanagan Mission
Okanagan Lake
Tp 25
Tp 27
Tp 28
Tp 29
Hydraulic
OSOYOOS DIVISION OF YALE LAND DISTRICT
SIMILKAMEEN DIVISION OF YALE LAND DISTRICT
Jack Smith Lake
Rembler Creek
PACIFIC
CANADIAN
Marina
Lookout
L 2711
119°15'00"
49°46'00"


50°06'00"
119°32'00"
49°56'00"
119°15'00"
Nahun
Caesars
OKANAGAN
PROVINCIAL
FOREST
Girl Guide Camp
TFL 9
Horseshoe Gulch
Wilson Landing
TREE FARM LICENCE 9
Traders Cove
OKANAGAN LAKE
1123±
City Limits
Okanagan Centre
Abandoned
Pumping Station
Kelowna City Limits
Tp 20
Tp 23
Bible Camp
Lightblue Lake
Dump
Walroy Lake
WOOD LAKE
Motel
Pumping Station
Trailer Park
Marina
Winfield
Woodsdale
Senior Citizens Home
Recreation Centre
Lumber Yard
DUCK LAKE INDIAN RESERVE 7
Reservoirs
Settling Ponds
Distillery
Underground Reservoir
Sawmill
Vernon
Air Beacon
Ellison Lake
Postill
Kelowna Airport
Tree Nursery
Robert Lake
Ellison
Pumphouse
Tp 21
Tp 24
Echo Lake
Echo Creek
WRINKLY FACE CLIFF
Clark Creek
Horse
Kelowna Creek
Whelan Creek
Creek