Calculating Small Area Analysis:
Definition of Sub-regional Geographic Units in Alberta

Geographic Methodology Series No. 5

Prepared by
Health Surveillance Branch
Alberta Health and Wellness
Edmonton, Alberta

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Alberta
HEALTH AND WELLNESS

For more information contact:

Health Surveillance
Alberta Health and Wellness
P.O. Box 1360
10025 Jasper Avenue
Edmonton, Alberta
T5J 2P4

Phone: 780-422-4518
Fax: 780-427-1470

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Note: Users of the information presented in this document in the analysis of health data must insure that products conform to the Alberta *Health Information Act*.

Executive Summary

This document is part of a family of reports that illustrates and documents the geographic methods required to properly analyze health data in Alberta. The descriptions and methods used are consistent across these reports. Together they provide all needed information required to properly understand the spatial component of health data.

This report describes the development of geographical regions smaller than the Health Region but larger than Enumeration Areas suitable for small area analysis in Alberta. Example analyses are also presented.

Acknowledgments

The following team prepared this report:

Alberta Health and Wellness

Erik Ellehoj	Geographic Information System Consultant
Dr. Donald Schopflocher	Biostatistician

The team acknowledges individuals in all of Alberta's Health Regions for the time and effort they expended in helping to establish sub-regional boundaries, and in supporting and reviewing this work.

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I. Background

A set of 17 Regional Health Authorities (RHAs)- were created in 1994 for the purposes of administering the health care system. The boundaries for these regions were revised in 1996 and again in 1998. In 2003, these regions were amalgamated into 9 regions.

Examination of geographic differences in the rates of health events is difficult because:

- The populations for RHAs range from less than 70,000 to more than 1,000,000. Since the precision of calculated rates for health events is inversely proportional to total population RHA to RHA comparisons become difficult;
- RHAs differ dramatically in area;
- The redesign of RHA boundaries completed in 2003 has created difficulty in examining spatial patterns of many health events as the amalgamation of larger populations over larger areas makes differences between them more difficult to characterize; and
- A suspicion is frequently voiced that the observed rate for any particular health event may differ from one part of an RHA to another.

The current report describes a project undertaken as a step towards a better understanding of the geographic differences in health and health determinants in the Province of Alberta.

There have been previous attempts within Health Surveillance to examine patterns across geographic units smaller than the RHA

- postal code areas, and
- latitude longitude blocks

Postal codes areas vary too widely in population to allow the calculation of stable rates. As well, many postal codes have very small populations, which causes concerns over data confidentiality. Finally postal codes have indefinite boundaries.

Latitude Longitude blocks may be an effective method for long term surveillance because there will be no change in the definitions of reporting units over time, and therefore no need to recalculate rates for historical data when boundaries change. They are particularly well suited to the representation of data that does not depend upon population (such as environmental exposure levels) and possibly to the comparison of environmental and health data. But since the blocks were designed to be consistent in geographic size, the populations of these blocks vary substantially in population and also present difficulties for the standard reporting of health event rates. (A variable size tile version is being examined to determine whether it can overcome this shortcoming). Finally, the latitude longitude tiles do not mesh with RHA boundaries. A separate report describes this technique in greater detail.

The geographic amalgamation level suggested for the spatial analysis of health events is summarized below:

Analysis	Geographic Unit
Case Management	Postal Code, Address
Common Health Events	Sub-RHAs
Rare Health Events	RHA
Very Rare Health Events	Province

II. The Need for Sub-RHAs

Before the 2003 RHA amalgamation, many RHAs had expressed interest in creating divisions smaller than the RHA in order to target certain regions within the RHA for specific programs. In fact, some of the RHAs had created such boundaries for administrative or analytical purposes. For health surveillance purposes, these sub-RHA units must maintain sufficient population sizes to allow the calculation of stable rates of health events. For this project, each of the nine (then new) Regional Health Authorities was contacted to solicit participation in the development of subRHA regions.

III. Method

All RHAs were examined with the goal of creating a set of sub-RHA boundaries. A population of 20,000 was chosen as a minimum within each subregion in order to ensure stable rates and other measures. A provisional set was created for all nine regions by Health Surveillance to examine the utility of subRHA analysis. Selected morbidity data was aggregated to these boundaries and the patterns that became visible indicated that this approach had potential utility. (The project began before amalgamation and the initial set of subRHA boundaries were based upon 17 RHAs. Work on the project was repeated after amalgamation to 9 RHAs).

The provisional sub-regional boundaries were created at Alberta Health & Wellness without input from the regions. It was clear, however, that local input would enhance the quality of the subregions for use by and within the RHAs. Each of the nine Regional Health Authorities was contacted to obtain candidate subregional boundaries and to determine appropriate timelines. Some of the RHAs had subregional boundaries available since they had created such boundaries before amalgamation and their boundaries did not change dramatically during amalgamation. Thus, Chinook's boundaries did not change at all and it was possible to use their subregional boundaries without changes. Palliser boundaries were slightly expanded and their subregional boundaries were stretched to incorporate the added territory. Capital (Region 6) boundaries were expanded to include two new rural areas and one urban area, which they added as three new subregions to an existing set of subregions.

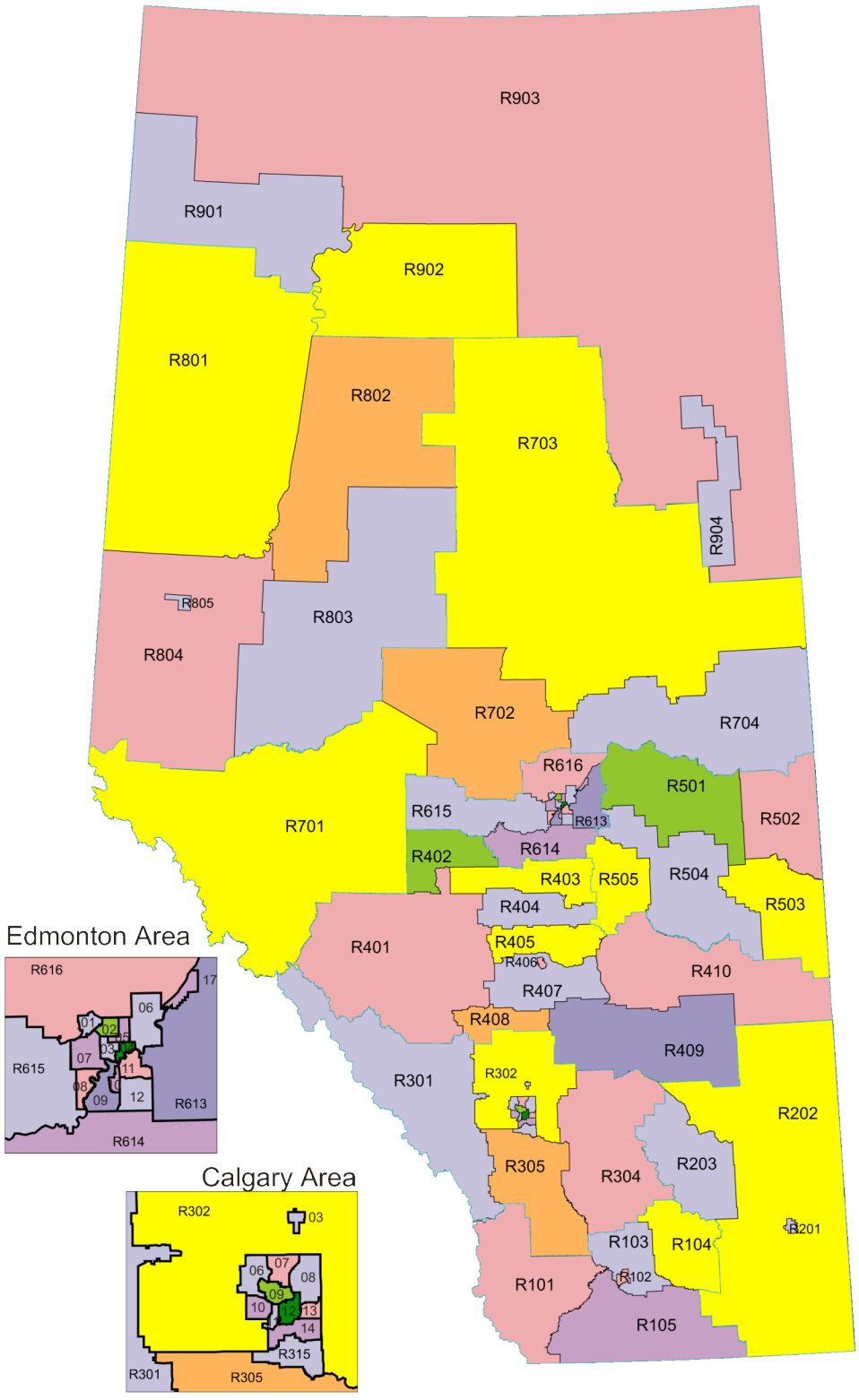
Other regions faced great challenges in merging operations from separate territories, systems, etc. Assistance was offered to these regions for the creation of boundaries that

were suitable for both provincial health surveillance and regional needs. All regions submitted subregional boundaries within two months, (thus exceeding all expectations and providing further evidence of the potential utility of these subregional boundaries). The subregional boundaries were based on municipal boundaries in some RHAs and in others they were based on hospital catchment areas.

Communicating with the appropriate responsible party in each region proved challenging in some cases since the task of creating subregions does not naturally fall in a single portfolio or to a single individual in most cases. As well, the amalgamation had caused uncertainty about job responsibilities and overlaps. Despite these issues, all regions were extremely cooperative and their efforts are gratefully acknowledged.

Figure 1 illustrates the subregions created by each RHA at a provincial level, while table 1 lists the subregional IDs and their respective populations.

Figure 1: Subregional boundaries



IV. RHAs vs SubRHAS with Health Data

The next phase of the project was to compare health data on RHA and sub-RHA boundaries. Morbidity data were obtained at the postal code level from Alberta Health and Wellness Hospital Morbidity files for the 2001-2002 fiscal year (April 1 2001 to March 31 2002). A fuller explanation of this process can be found in The first report in this series: "Calculating Demographic and Epidemiological Quantities in Alberta by Geo-Political Area".

A number of different health event types were chosen for examination in the hope of generating a variety of patterns. These were:

Health Event	**Case Definition (ICD9 Code)**
Asthma	493.*
Depression	296.*
Appendicitis	540.*
All hospital admissions	

Although these are relatively unsophisticated case definitions, they are useful in demonstrating the utility of the technique. (Note that this report is not intended to accurately represent the health states or events listed above. Fuller case definitions would generally be needed for that purpose. It should also be noted that a variety of normal data quality analyses and cleansing processes were also not performed).

Congenital anomalies (inpatient hospital data) data were also examined for the same time period, specifically cleft palate or cleft lip, heart septal anomalies, Down's syndrome, and all anomalies combined. This later set of numbers provides a challenge to the technique because they are rare health events.

The maps in the following pages reveal some surprising patterns present in the data and highlight the potential benefits of using subRHAboundaries.

The maps were created using a methodology consistent with Alberta Health Trends (2001) and described in detail in another report in this series. The map classification is based on a score calculated using regional rate, provincial rate, and regional standard error and is explained below.

Method for Mapping Disease

The method described below has been used for a number of reports published by Alberta Health and Wellness Surveillance. All maps generated in "Health Trends in Alberta" and all maps in this report use this method.

This method was developed in order to address some issues associated with the variations in population in the Regional Health Authorities (RHA) in Alberta. The population size of a RHA will affect the rate stability associated with that region, rates will be more unstable for a small population than for a larger population. The method described below is designed to deal with these issues and present the data in a more statistically consistent manner.

The method consists of several steps:

a) Calculate the rates for each region.

b) Calculate the rate for the province.

c) Calculate standard error of a probability of a health event for each regional rate using the following formula:

$$\sqrt{\frac{p(1-p)}{n}}$$

Where: p is the rate (estimate of probability) for the region
n is the number of births for 1 year OR
the summed births for a multi-year calculation
(n is total population for other health events)

d) Calculate the regional specific standard scores. This is accomplished by subtracting the regional rate from the provincial rate and dividing these by the standard score derived for each region in step 3. This is repeated for every region

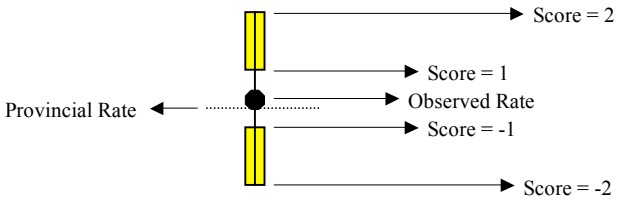
$$\frac{\text{regional rate} - \text{provincial rate}}{\text{regional standard error}}$$

e) Graph the standard scores calculated in step 4:

Score	Interpretation	Colour
> 2	Significantly Higher than Provincial Average	Red
1 to 2	Higher than Provincial Average	Orange
1 to –1	Average	Yellow
-1 to -2	Lower than Provincial Average	Light Green
< -2	Significantly Lower than Provincial Average	Dark Green

The black dot represents the value of the rate for each region. The colour of the bars above and below the dot represent the score of the region. The portion of the bar closest to the black dot represents the value for a standard score of 1 or –1, while the part of the bars farthest from the dot represent the value for a score of 2 or –2. end

Figure 2: Rate and Standard error



The figure above illustrates how to interpret the graphic for an individual region. The yellow bars are used to show that provincial rate crosses between the 1 and –1 score range. The table lists other colour possibilities by score category.

f) Generate map using the same categories for each region as listed in step 5.

The methodology used for the subRHA maps in this document is identical to that listed above. The rate and standard error of each sub-RHA are used along with the provincial rate for the same health event and time period.

Morbidity data

This section presents a brief annotation of the maps and comparison of the RHA and subRHA patterns.

All Morbidity

The RHA-level map for all morbidity shows only two categories: significantly lower than the provincial rate (Capital and Calgary) and significantly higher than the provincial rate (the remaining seven regions). This pattern is not surprising as in rural areas, patients are more likely to remain in hospital as travel to the facility involves greater effort than in large urban areas.

Examining the same data at the sub-RHA level reveal similar patterns, as the rural areas (lower population density) report values significantly higher than the provincial rate and thus are shown in red. Subregion R904 (Ft McMurray and vicinity) appears in orange in contrast with the other similar urban areas (Lethbridge, Medicine Hat, Red Deer, and Grande Prairie). These four urban areas are likely to attract some residents (i.e. migration toward urban areas) from nearby rural areas, as age increases, in order to have better access to more frequent medical services. Ft McMurray is unlikely to attract a similar population as there is a very small surrounding rural population.

Subregion R502 (Lloydminster) appears in orange since not all morbidity data is available within this region –the Lloydminster hospital is located in Saskatchewan and data from that hospital for Alberta residents was not available for inclusion in this analysis.

In Region 3 (Calgary), subregions R304 and R305 are not dark green since they include a larger rural population. Subregion R301 (Banff) also includes a larger rural component and thus deviates by one category from its expected membership. Subregion R313 is surprising as it appears in yellow (average –compared to the provincial rate).

In Region 6 (Capital) all rural subregions appear in dark green (significantly lower than the provincial rate), with the exception of R614 (Leduc County) which displays conditions similar to the provincial rate. One tile within The City of Edmonton reports a slightly higher rate of morbidity while another reports a rate significantly higher than the provincial rate.

The technique shows great consistency to the RHA-level mapping, while providing extra insight into the data, such as the missing data in Lloydminster or the unexpected high rate in a subregion within Edmonton.

Figure 3: All morbidity subRHA map

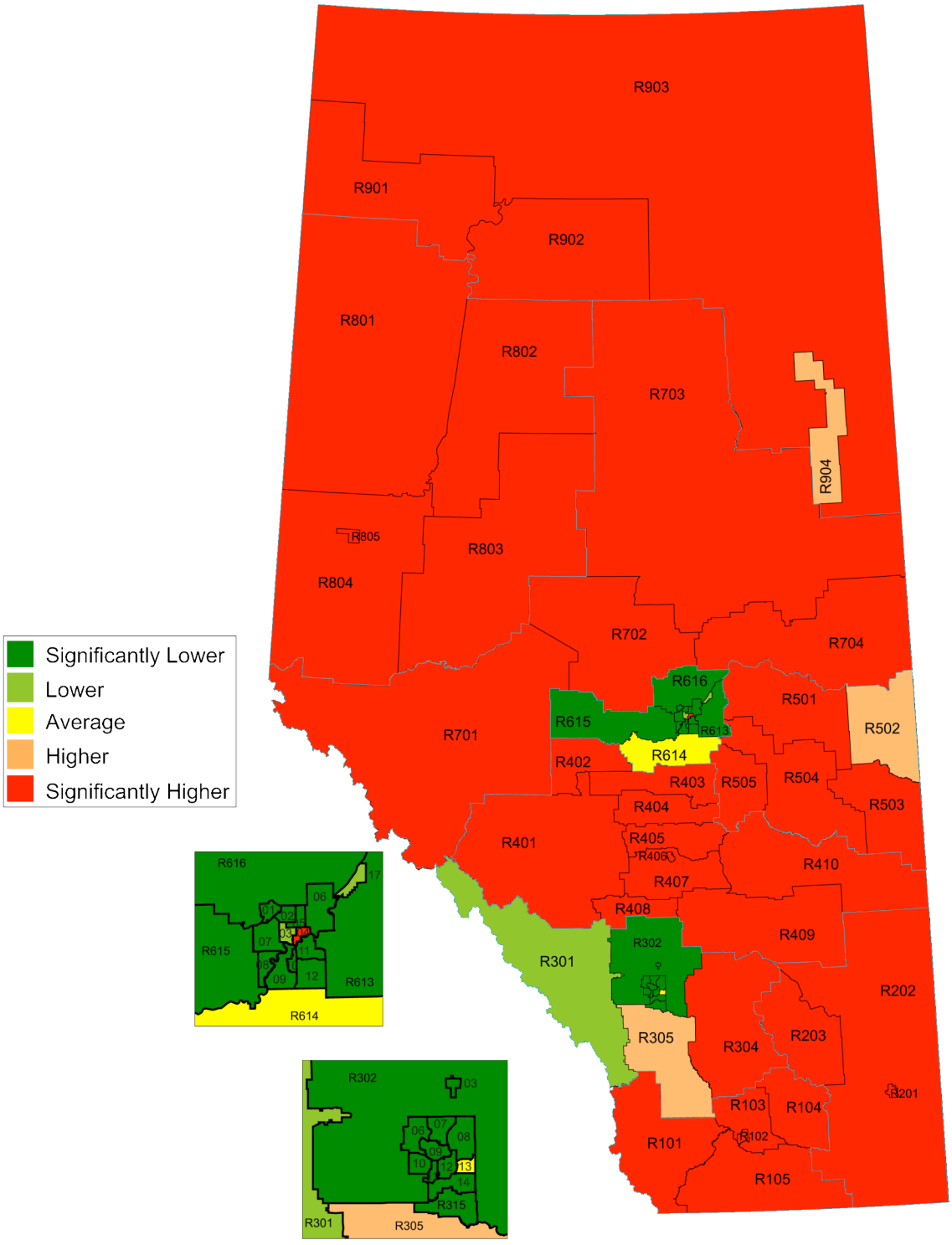


Figure 4: All morbidity subRHA graph

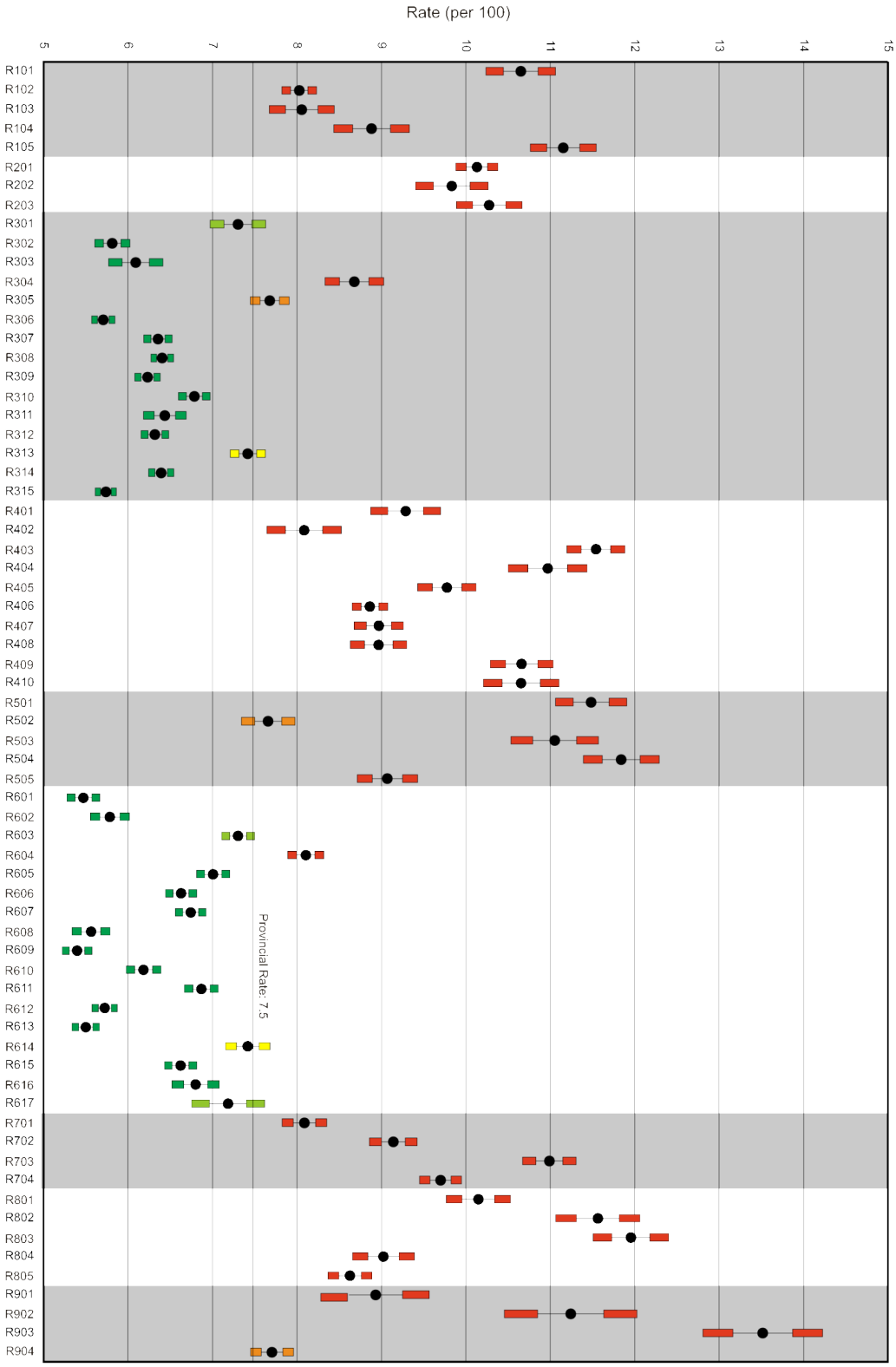


Figure 5: All morbidity RHA map

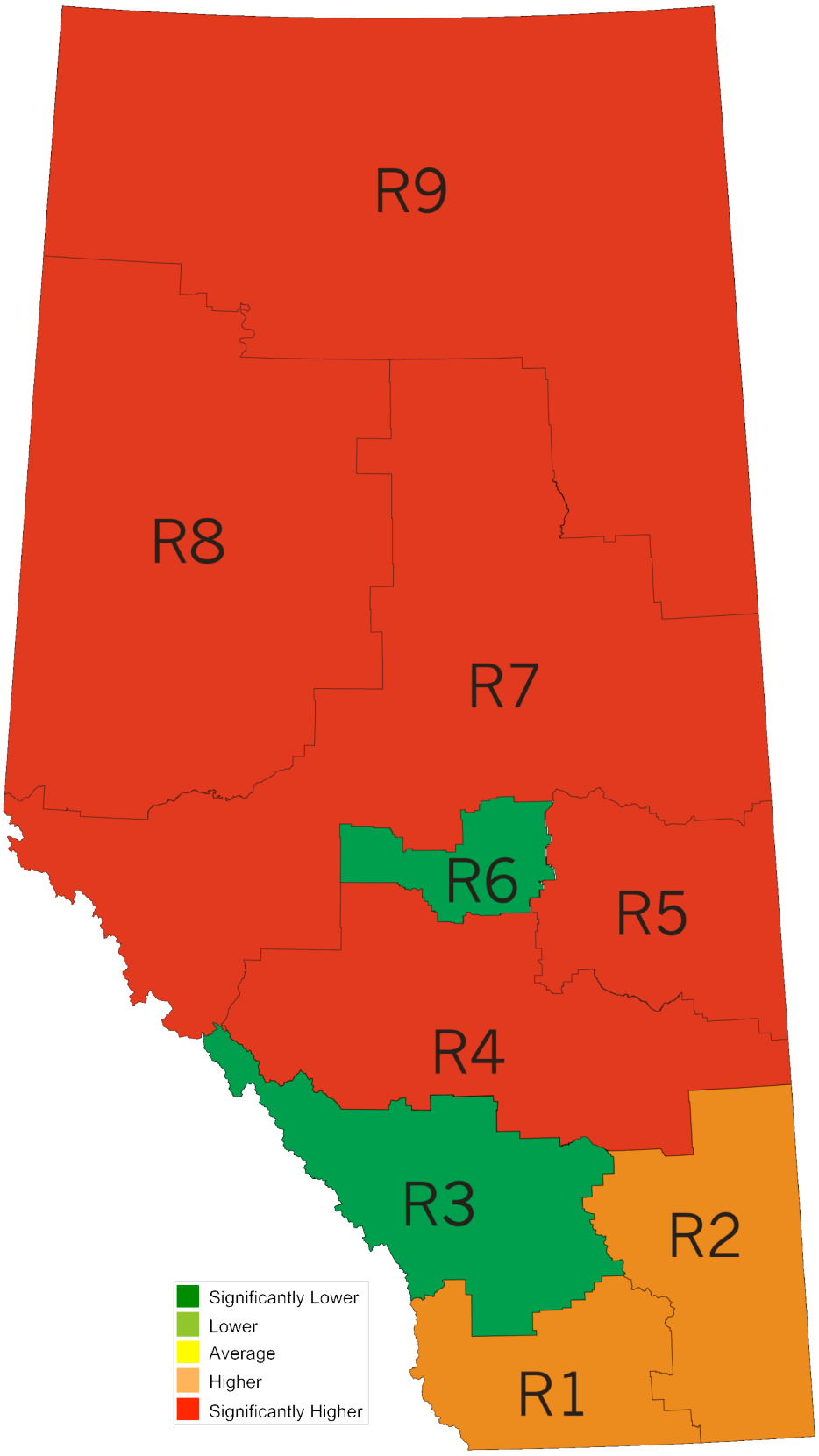
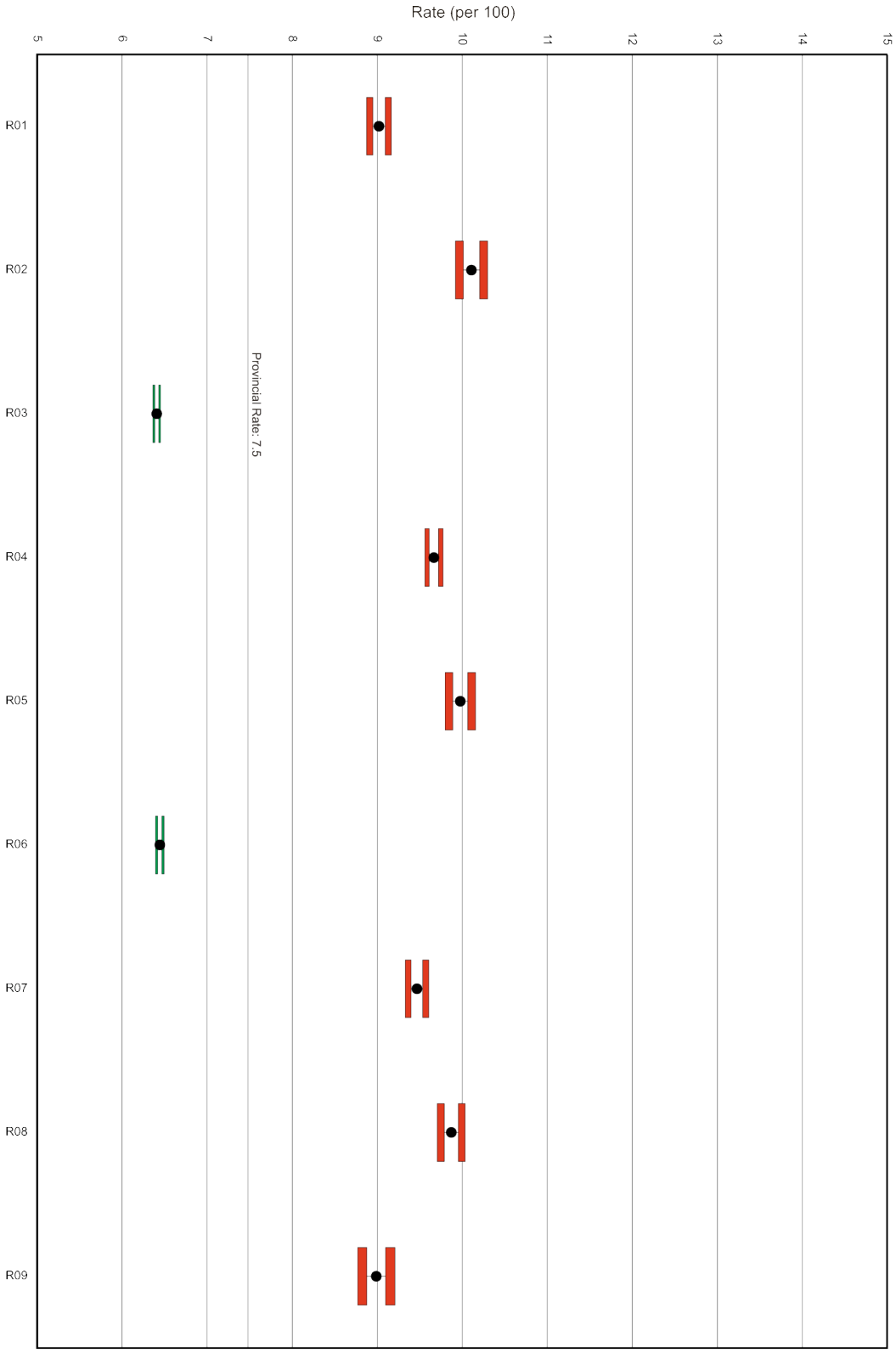


Figure 6: All morbidity RHA graph



Asthma

The RHA level maps for asthma are very similar to those created for all morbidity. Capital and Calgary report values significantly lower than the provincial rate, Northern Lights reports values within the provincial rate, and the remaining six RHAs report rates significantly higher than the provincial rate.

Despite the similarities at the RHA level, the asthma and all morbidity maps at the subregional level are very different. Northern Lights contains a subregion (R903) with a significantly higher rate, something that was not evident in the RHA-level map. Furthermore subregion R904 (Ft McMurray) reports a rate lower than the provincial rate, while the remaining two tiles report rates similar to the provincial rate and the RHA as-a-whole.

Region 8 (Peace Country) reports significantly higher than provincial rate at the RHA level, but the only subregion that reports in a similar category is R802. Subregion R804 reports conditions similar to the provincial rate.

Region 7 (Aspen) reports significantly higher, but only subregions R703 and R704 are within this category. Subregions R701 and R702 report conditions similar to the provincial rate.

In Region 5 (East Central), subregion R502 (Lloydminster) reports a value significantly lower than average, once again a data issue.

In Capital and Calgary there are a number of categories encountered, rather than the expected, consistent, “significantly lower” category. Region 3 (Calgary). three subregions report rates higher than the provincial average, including within the City of Calgary itself. All five data categories can be found within Region 3.

Region 2 (Palliser) is consistently high, while Region 1 (Chinook) reports one subregion in the “average” category R103, and another in the “higher than provincial rate” category R104.

The subregional map provides a great deal information to aid in the understanding of the spatial patterns in asthma morbidity data than that provided by RHA-level maps.

Figure 7: Asthma subRHA map

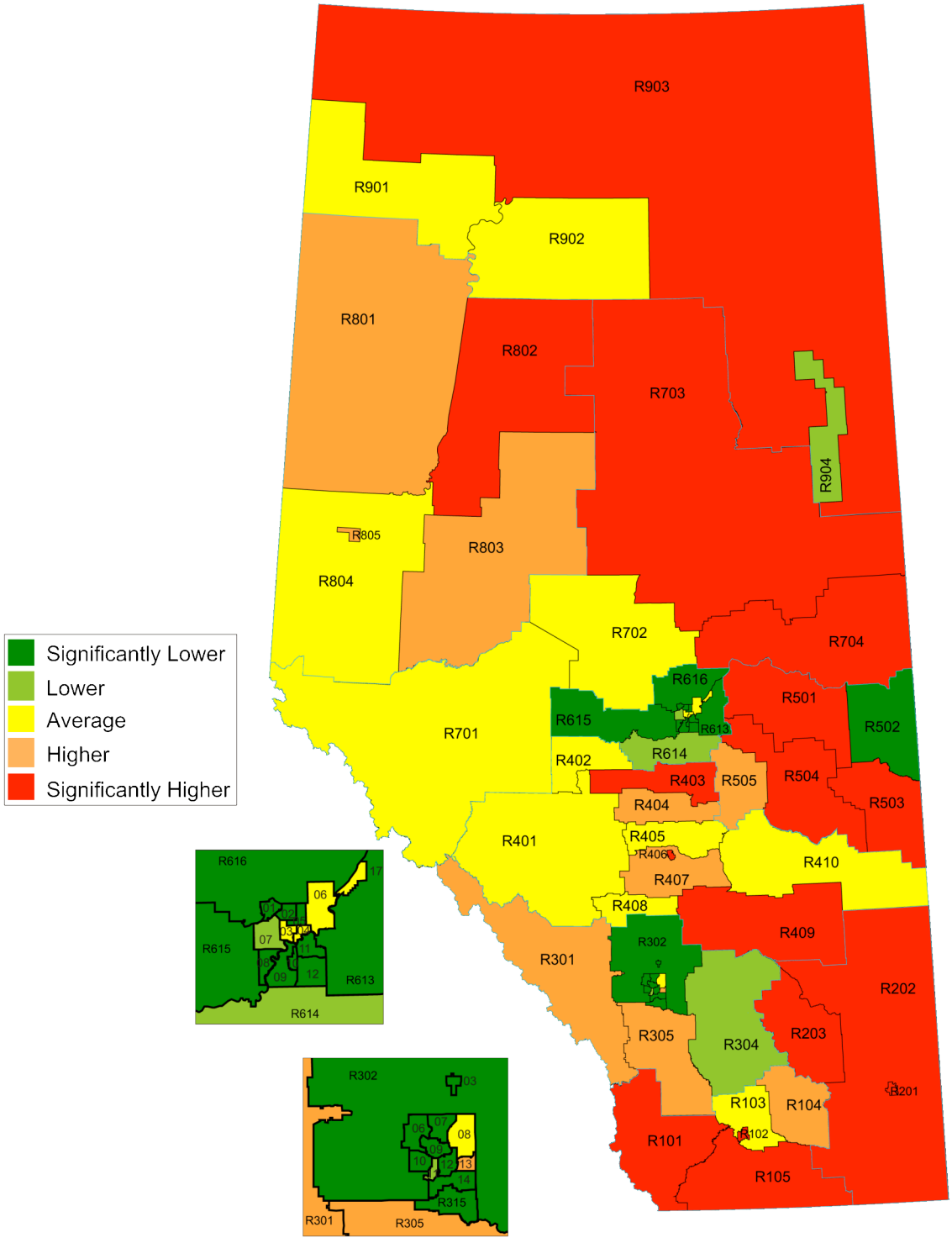


Figure 8: Asthma subRHA graph

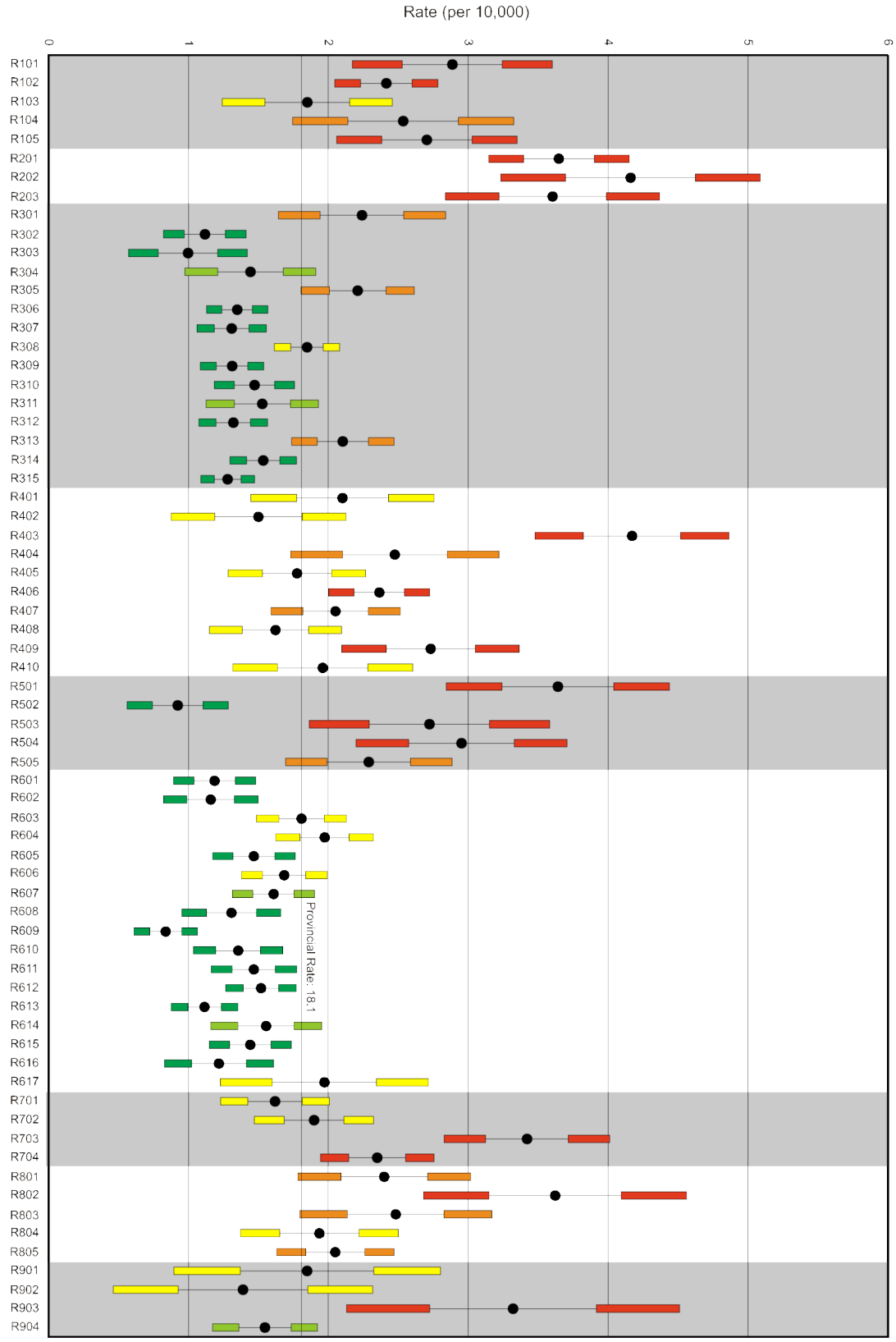


Figure 9: Asthma RHA map

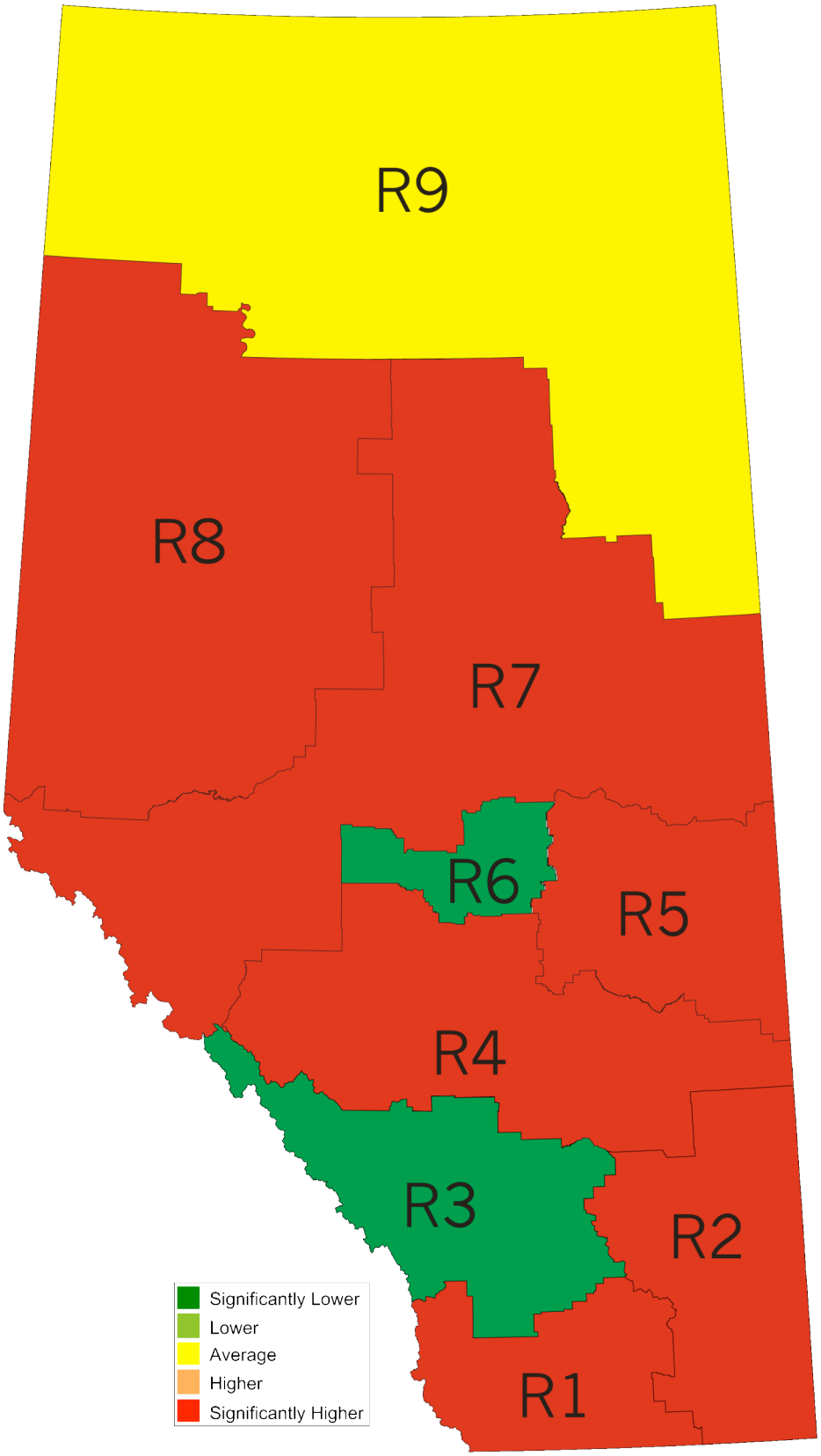
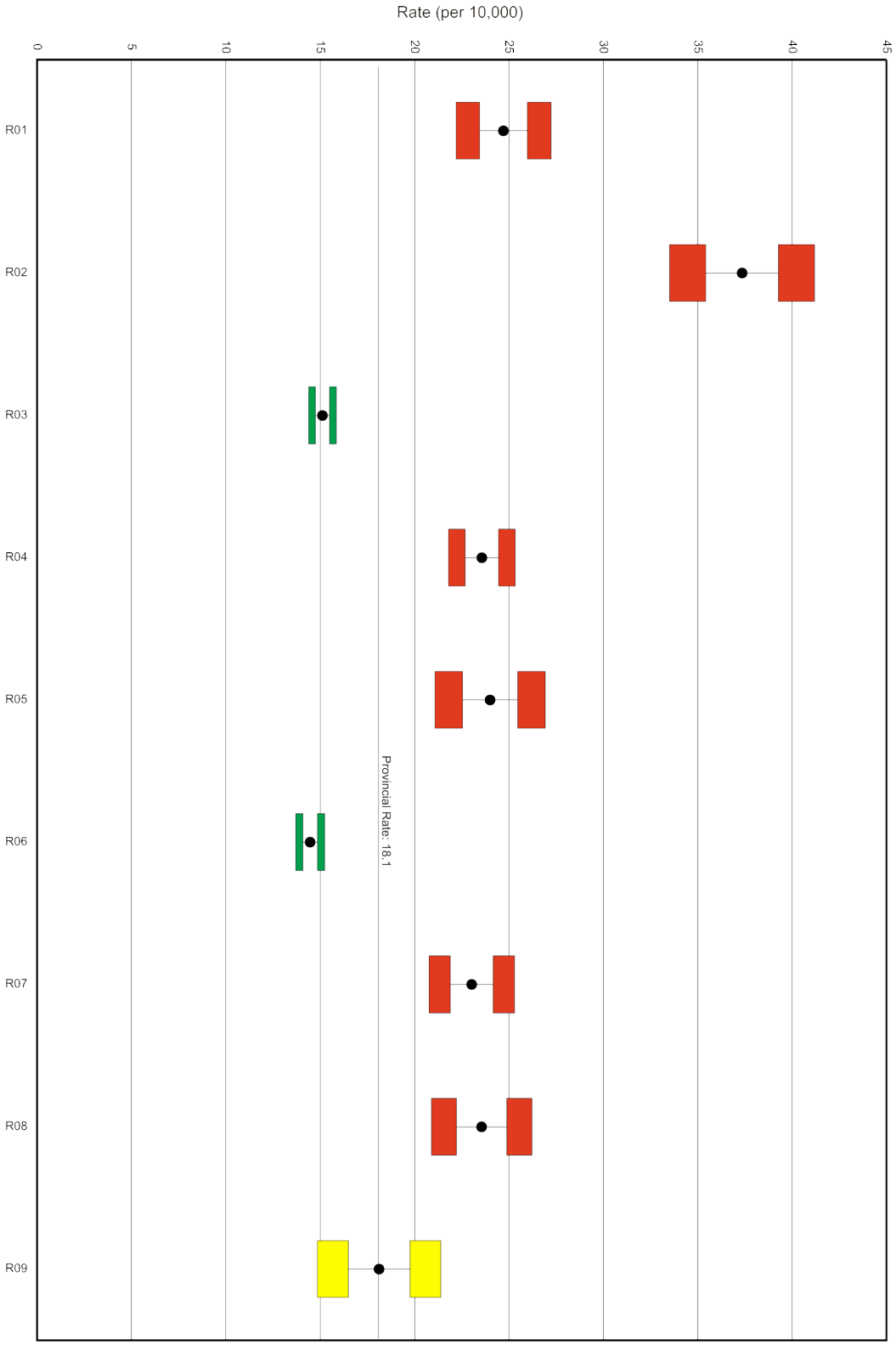


Figure 10: Asthma RHA graph



Appendicitis

This health event was chosen because it was anticipated that there would be few regional differences as there is little diagnostic latitude and it is not an elective procedure. The RHA-level map shows all 5 categories. (Please note in the graph that the two regions reporting in red and dark green do not have the highest and lowest estimated rates.)
At the subregional level, there is a greater proportion of "average" areas, which allows for analysis of those subregions that do not follow the pattern. R502 (Lloydminster) is lower than average for reasons already outlined. R904 (Ft. McMurray), R805 (Grande Prairie), and two Edmonton subregions report rates significantly lower than the provincial rate.

Neighboring subregions R304 and R203 report rates significantly higher than the provincial rate, an instance where two RHAs may want to address the issue together as it may be a "border issue". A number of subregions appear in light green and orange, but may not be all that different from some yellow areas (The colour differences may depend largely on population differences and therefore differences in the size of the standard error scores). **The graph must always be used in conjunction with the map in order to avoid misinterpretation of the information.**

The subregional map and graph provided much more information and highlighted those smaller areas that were responsible for altering the classification of RHAs. Region 4 (David Thompson) appeared in red at the RHA level, but not a single subregion was classified as significantly higher than provincial rate, yet "red" subregions appeared in two RHAs that were globally classified as "yellow".

Figure 11: Appendicitis subRHA map

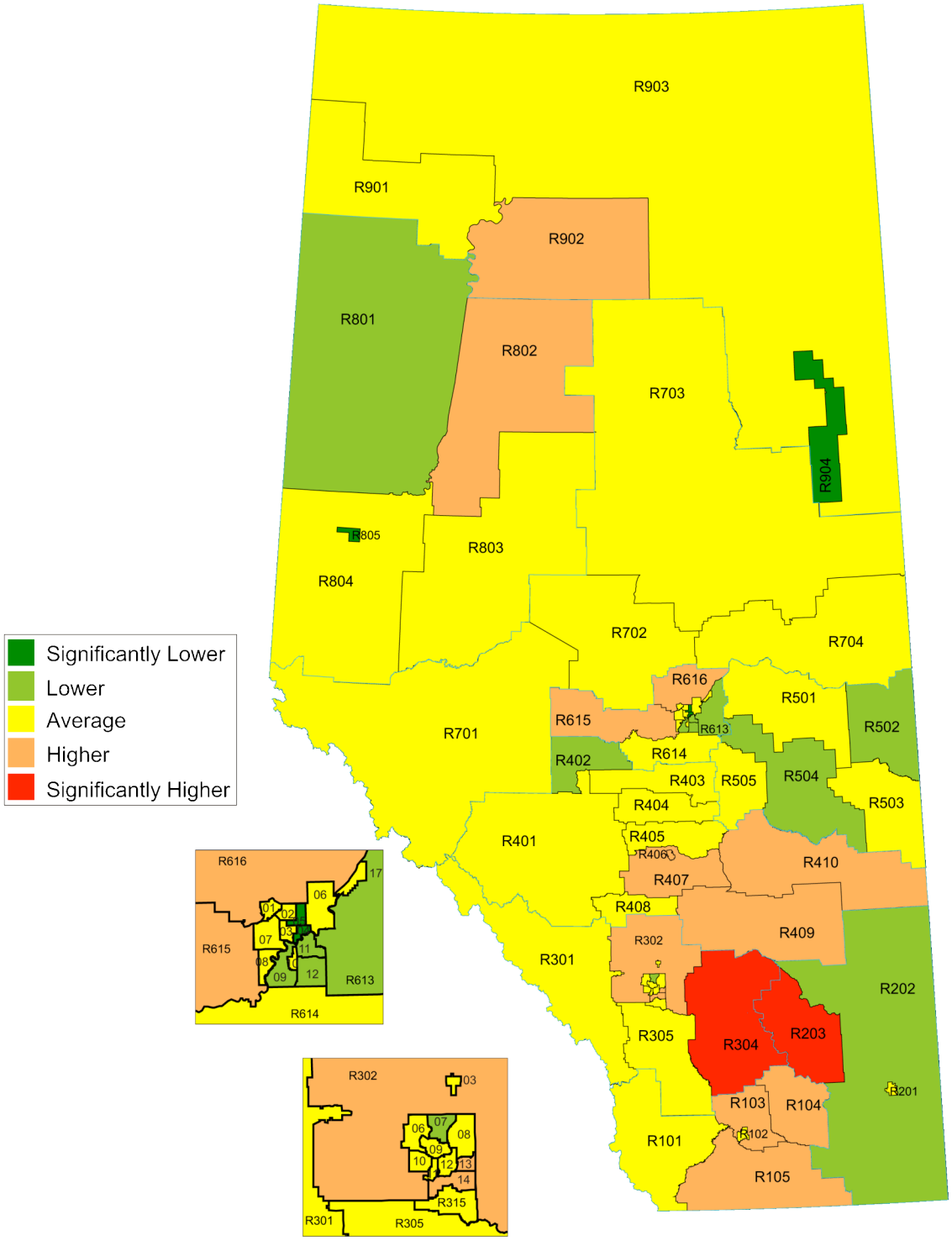


Figure 12: Appendicitis subRHA graph

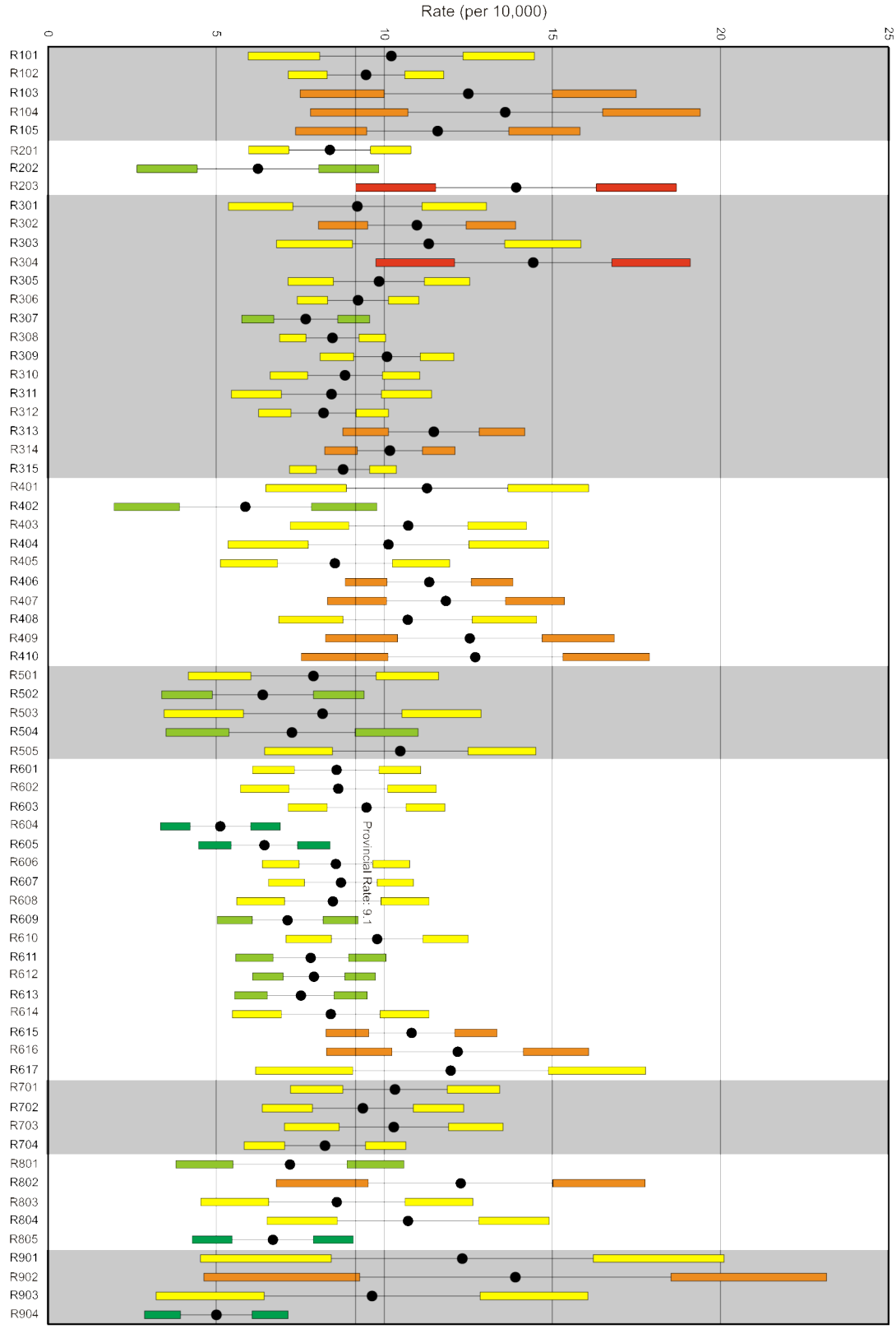


Figure 13: Appendicitis RHA map

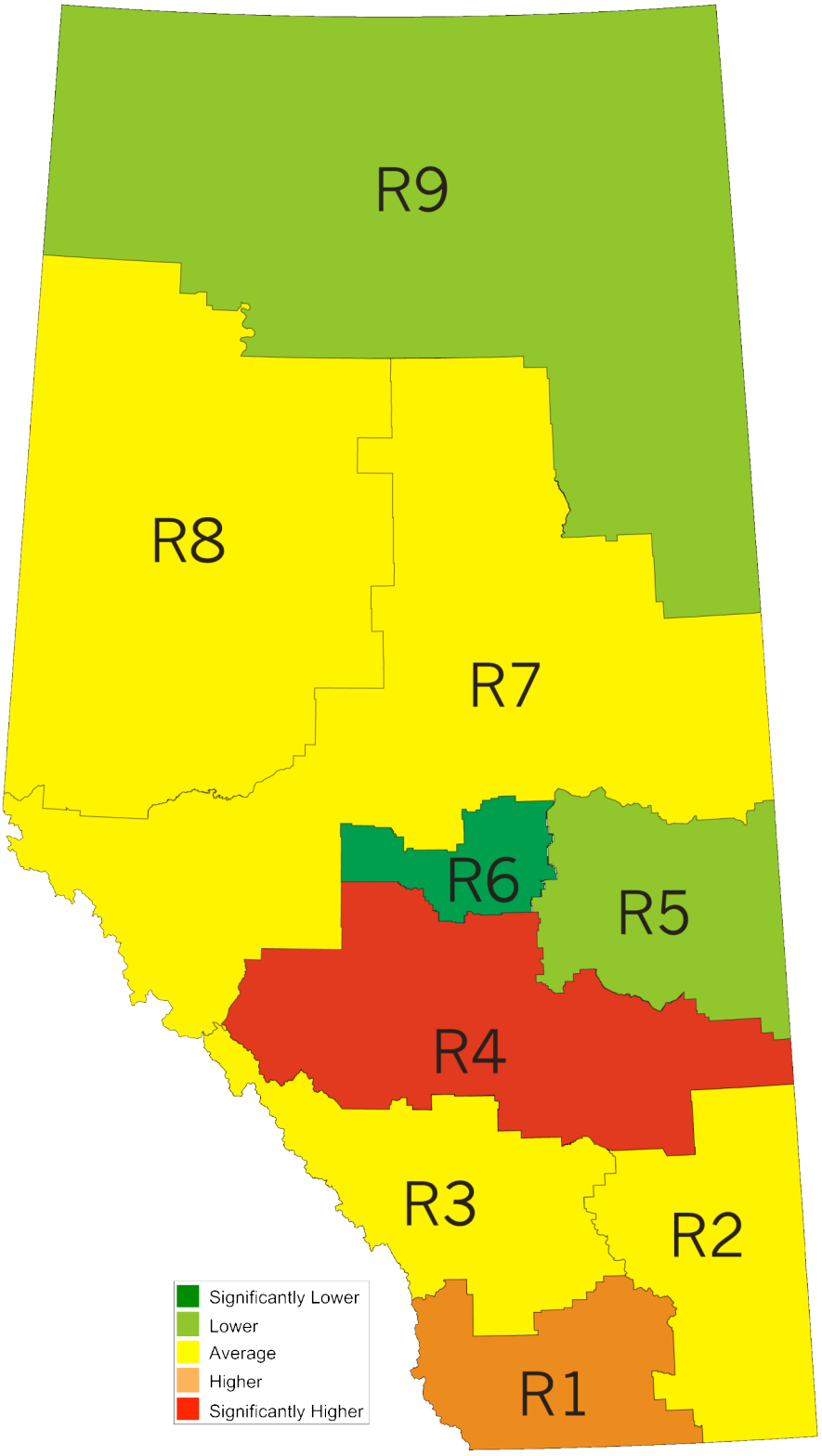
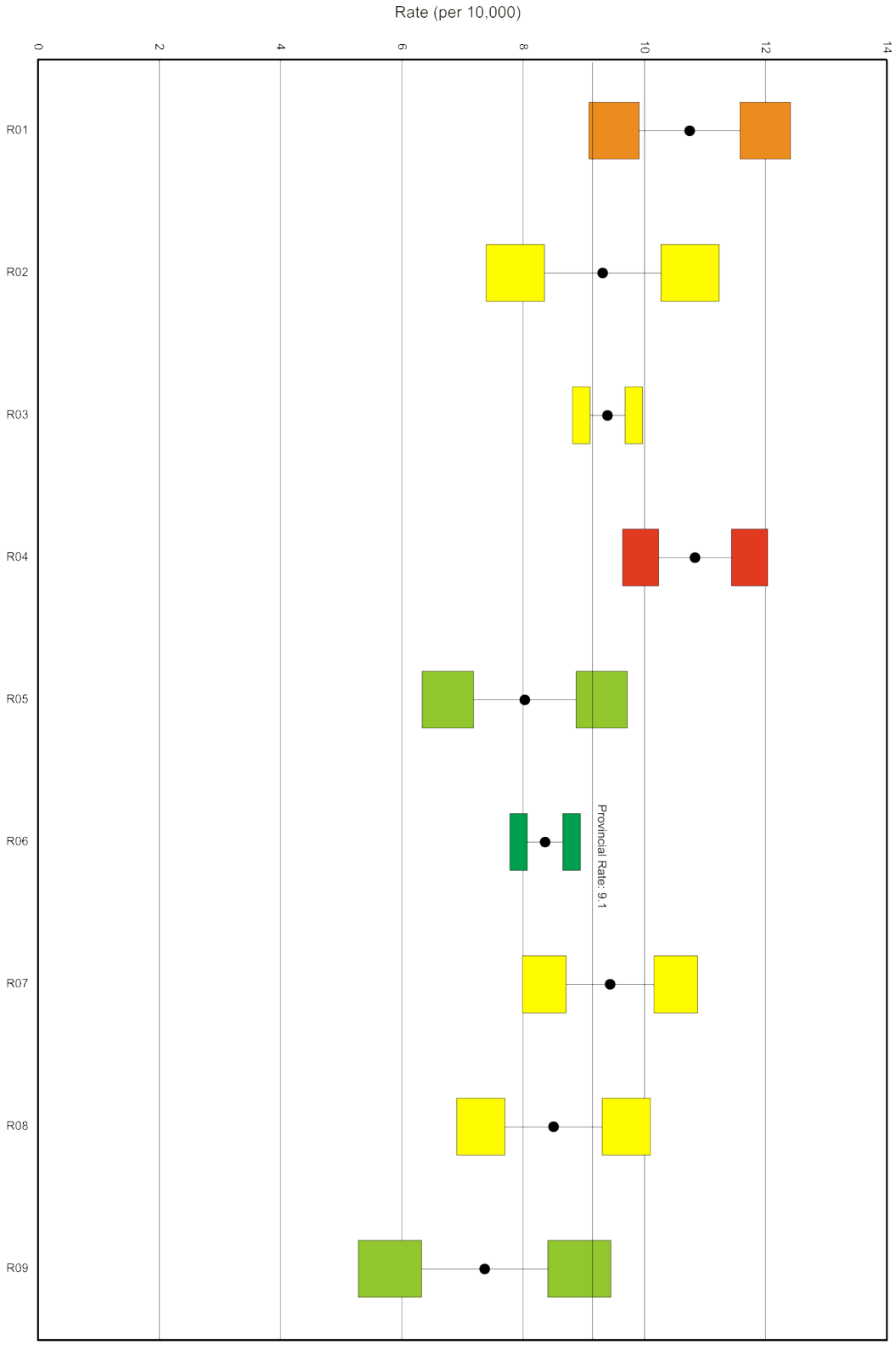


Figure 14: Appendicitis RHA graph



Depression

As has been mentioned before in this report, the case definition methodology used was adopted for ease of access to the data and may not be a true reflection of the health event in question. The data is only used to determine the suitability of the geographic aggregation method for a number of different circumstances. A number of other factors need to be considered in order to form an appropriate case definition for the analysis of a complex diagnosis, such as depression.

The RHA level map shows that this health event is more prevalent in rural areas than urban areas. Region 3 (Calgary) is significantly lower than average, while Region 6 (Capital) is average. Region 9 (Northern Lights) is lower than average, possibly as result of the influence of the relatively large urban population of Ft. McMurray.

The map at the subregional level shows a very different picture. There is a great variety of assignments to categories that form "regions" with similar characteristics regardless of their RHA membership. Subregions R902, R703, and R803 belong to three different RHAs and yet are neighboring areas which record rates significantly lower than the provincial average. The outskirts of Edmonton and Calgary form other clusters of the same category.

All of Region 8 (Peace Country) appeared in red in the RHA-level map, but only one subregion fits within this category –R805 (Grande Prairie), the largest urban portion of this RHA.
In Region 5 (East Central), three, out of four, subregions stand out with significantly higher rates than provincial rate. The fourth subregion corresponds to Lloydminster and the data issue already mentioned.

Edmonton had two subregions in the "red" category and three in the "orange" category.

Grande Prairie, Red Deer, Medicine Hat, and Lethbridge all report rates significantly higher than the provincial rate, but Ft. McMurray reports rates similar to the provincial rate.

The original interpretation of urban vs rural as an explanation of the patterns observed at the RHA levels proved to be incorrect once the information was analyzed at the subregional level. Many of the cities in the province (outside Edmonton and Calgary) recorded rates significantly higher than the provincial rate. Many rural tiles appear in light or dark green and a large proportion report "average" conditions. **The subregional map and graph demonstrate that there are dangers at interpreting aggregated data (at the RHA level) based on perceived patterns without fully investigating these patterns at a finer level of aggregation.**

Figure 15: Depression subRHA map

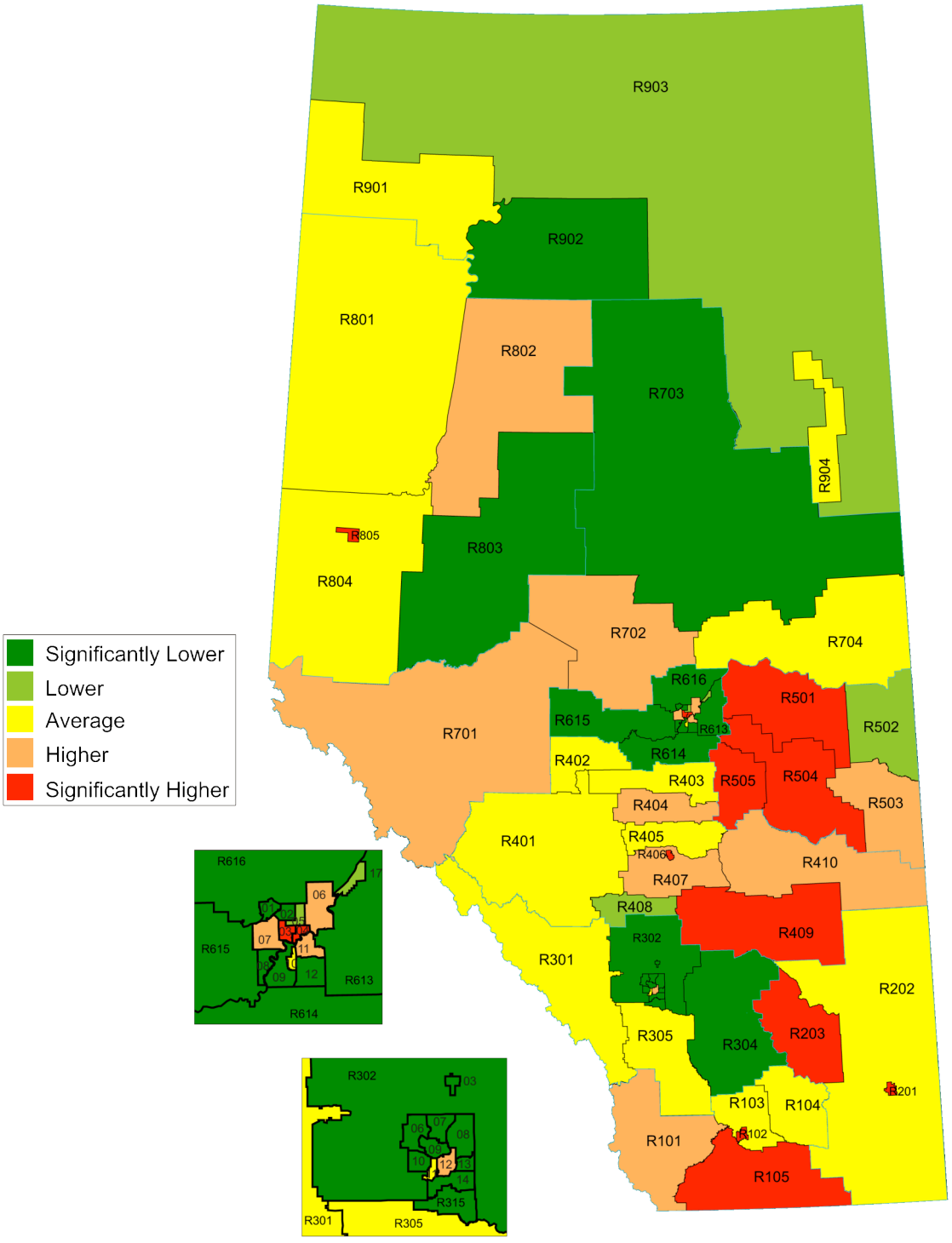


Figure 16: Depression subRHA graph

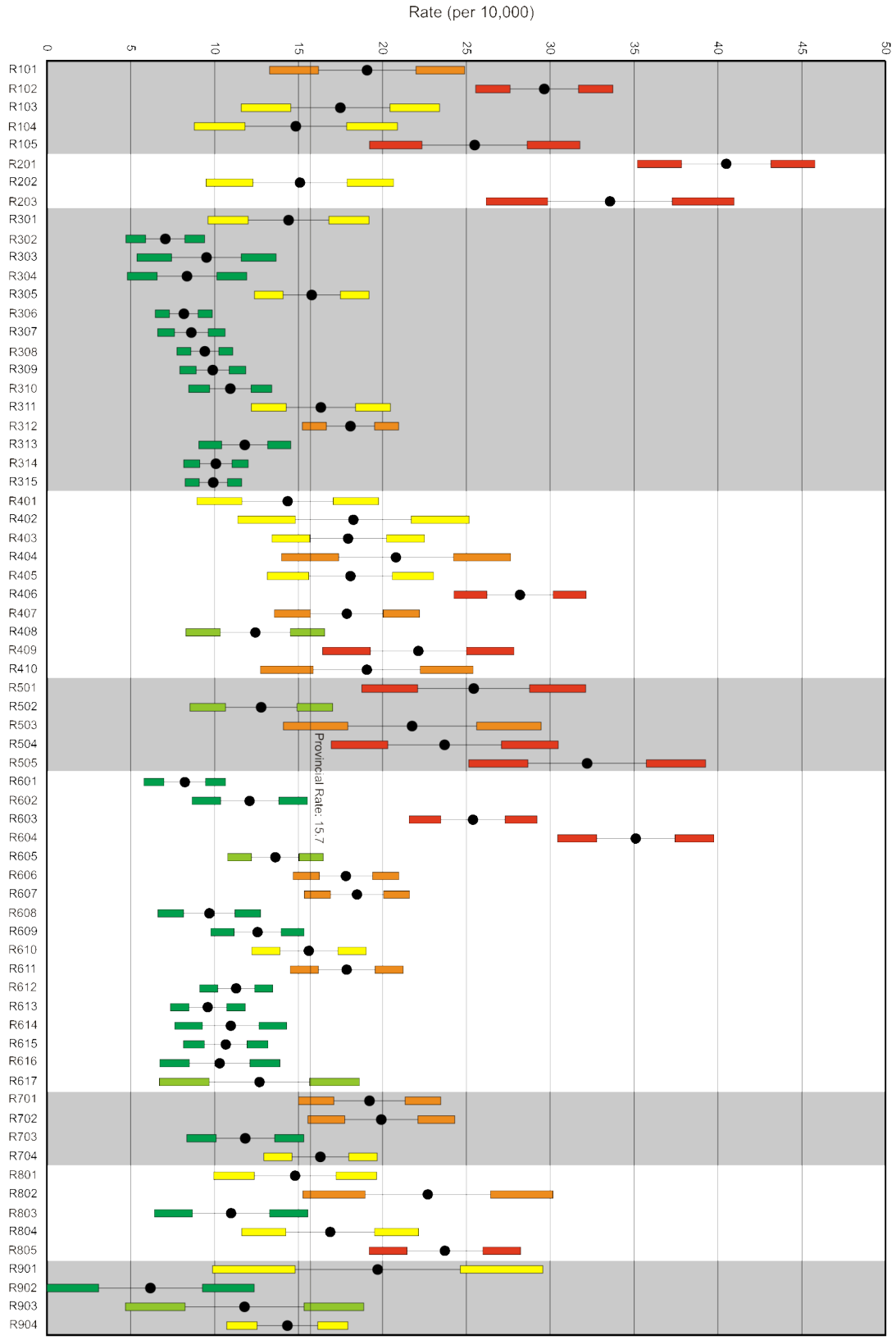


Figure 17: Depression RHA map

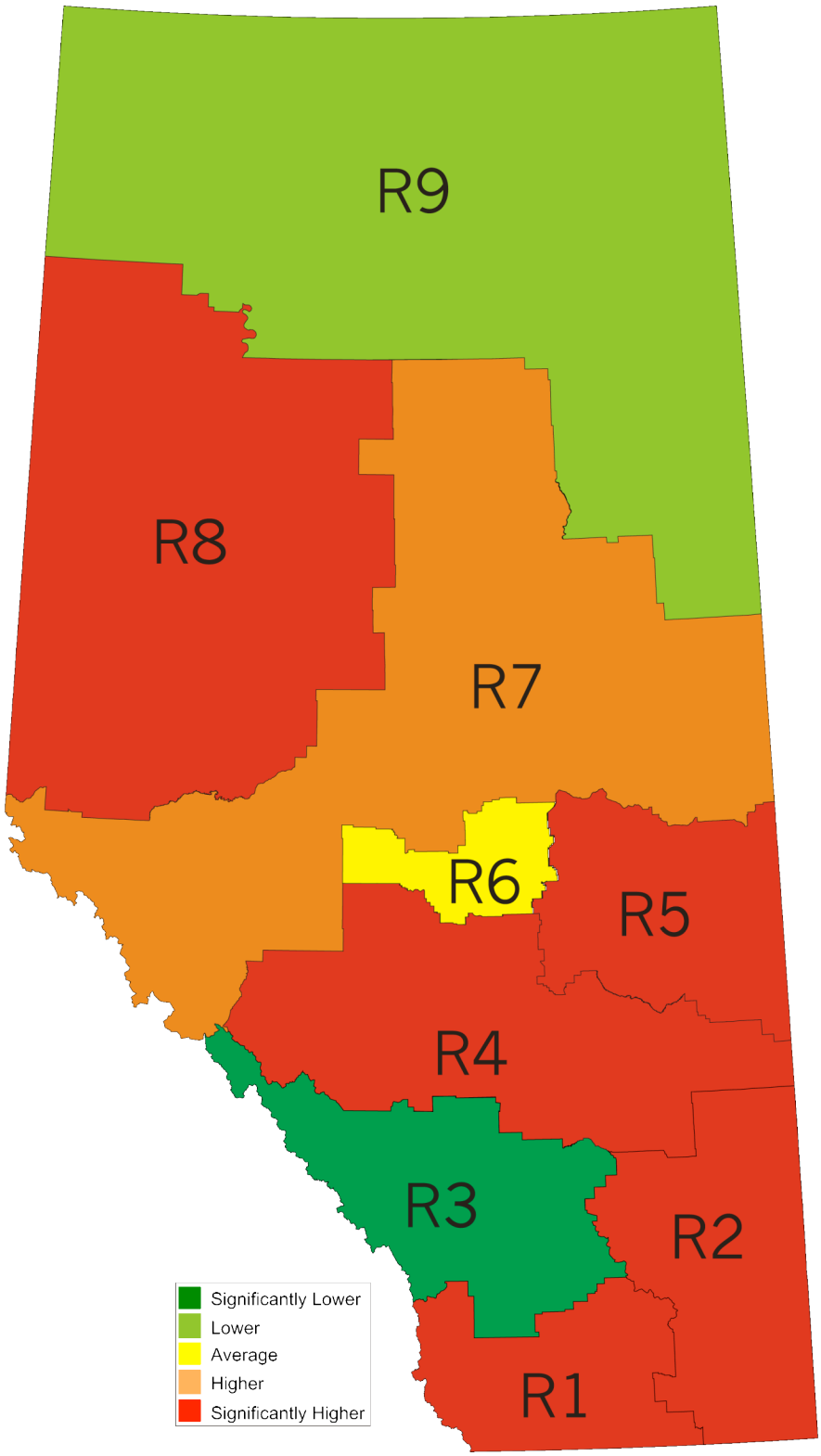
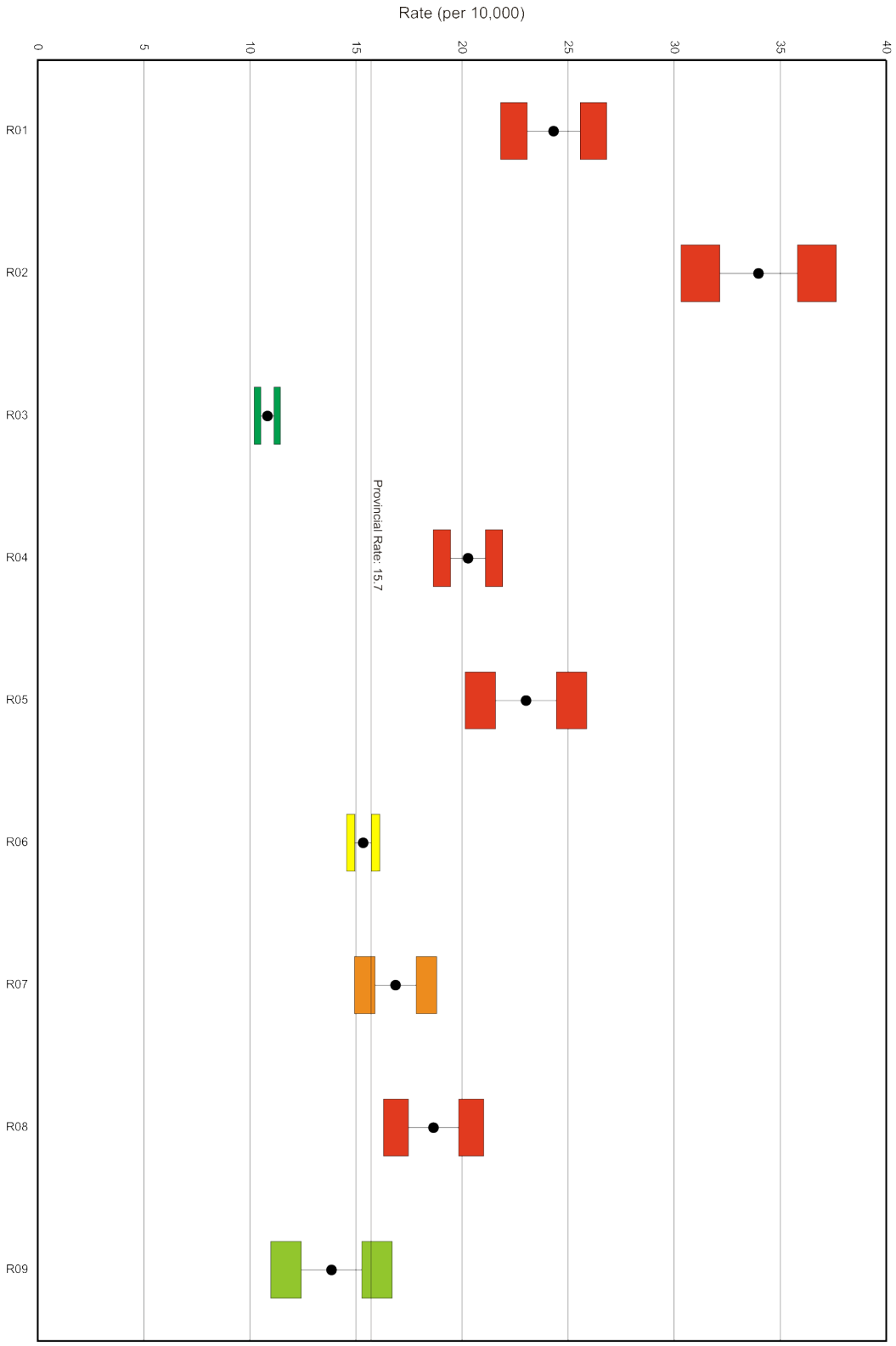


Figure 18: Depression RHA graph



Congenital Anomalies data

All Congenital Anomalies

This data consists of all congenital anomalies recorded for the 2001-2002 fiscal year. These anomalies are recorded by the hospitals where the deliveries were performed and thus may not reflect the true pattern of these anomalies as the level of reporting varies from facility to facility.

All congenital anomalies aggregated show an interesting pattern at the RHA level, as Regions 4, 5, and 6 report lower rates than the rest of the province. Region 9, 8, and 3 have the highest rates.

At the subregional level, the pattern is quite different. Subregions R903, R304, and R105 are the only rural subregions in the "red" category. The city of Grande Prairie and half of the City of Calgary also report in the same category.

The observed patterns for Regions 3, 8, and 9 are regionalized and there are dramatic differences within these RHAs, especially Region 3 (Calgary).

The pattern of lower rates for Regions 4, 5, and 6 is consistent and only subregion R408 is classified as higher than the provincial rate.

Regions 1, 2, and 7 are classified as "higher than provincial rate" yet these regions contain several subregions that report rates similar to the provincial rate.
Once again, the subregional map provides much more information than the RHA-level map and helps to narrow-down the source for some differences in the spatial pattern of a health event.

Figure 19: All congenital anomalies subRHA map

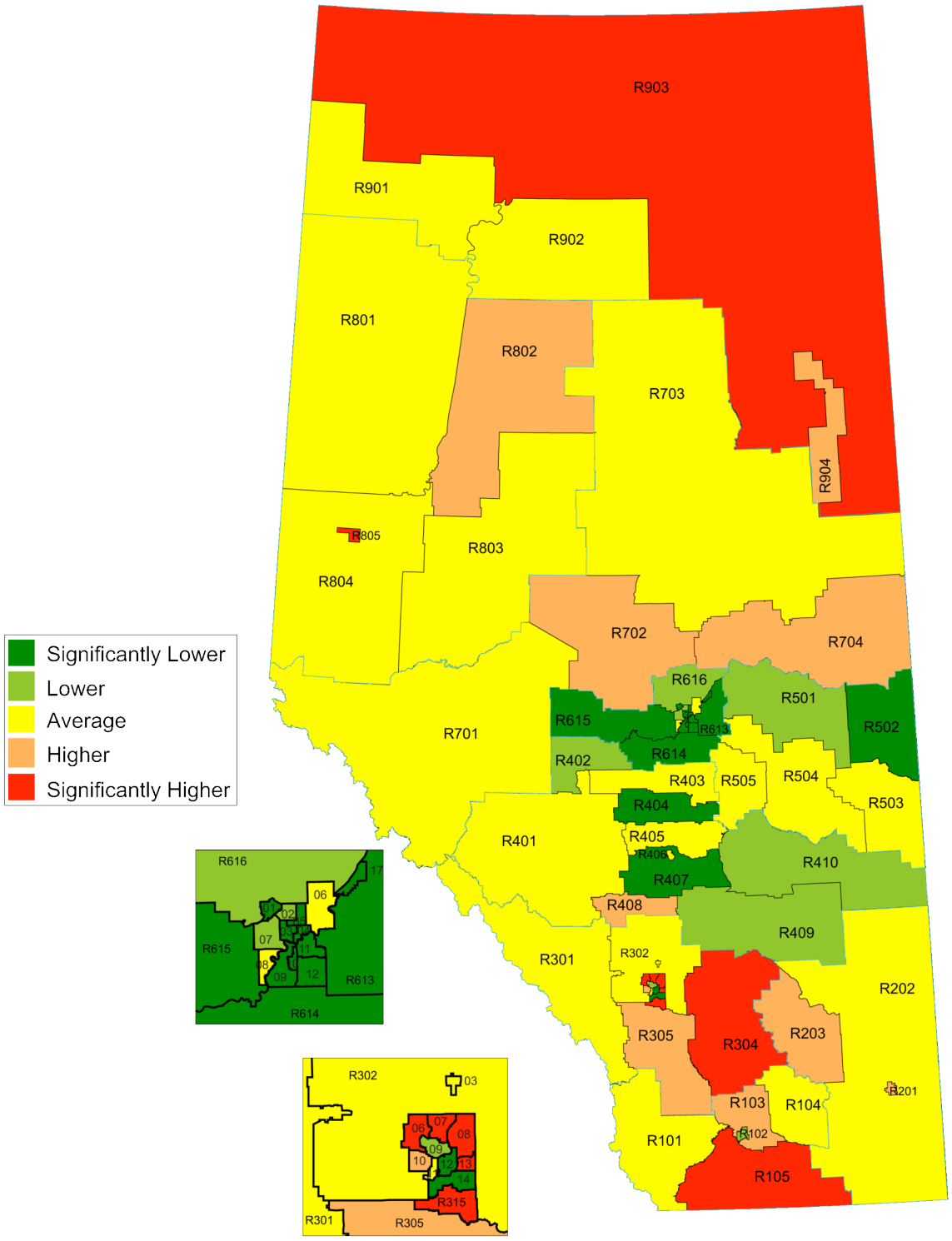


Figure 20: All congenital anomalies subRHA graph

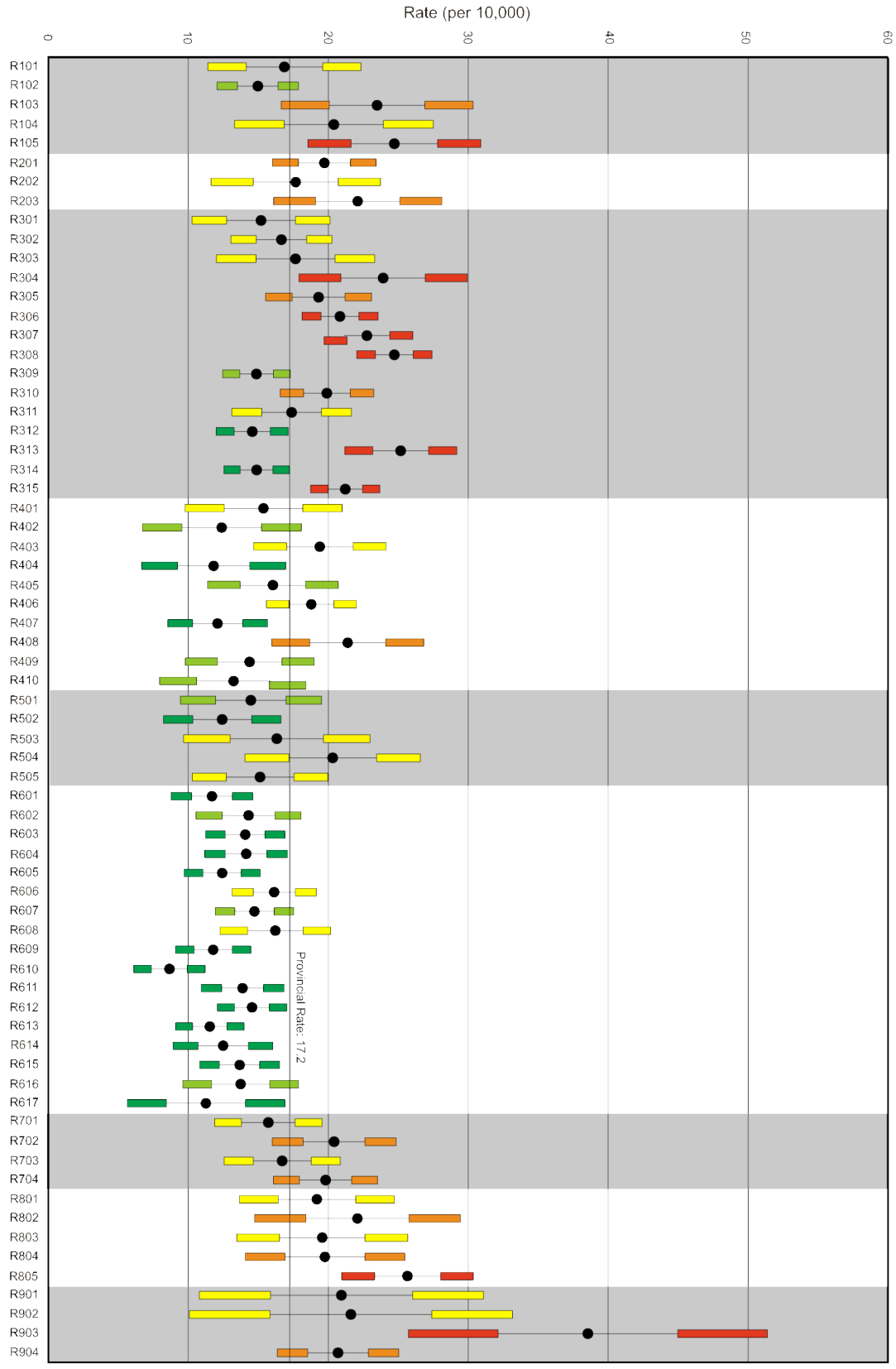


Figure 21: All congenital anomalies RHA map

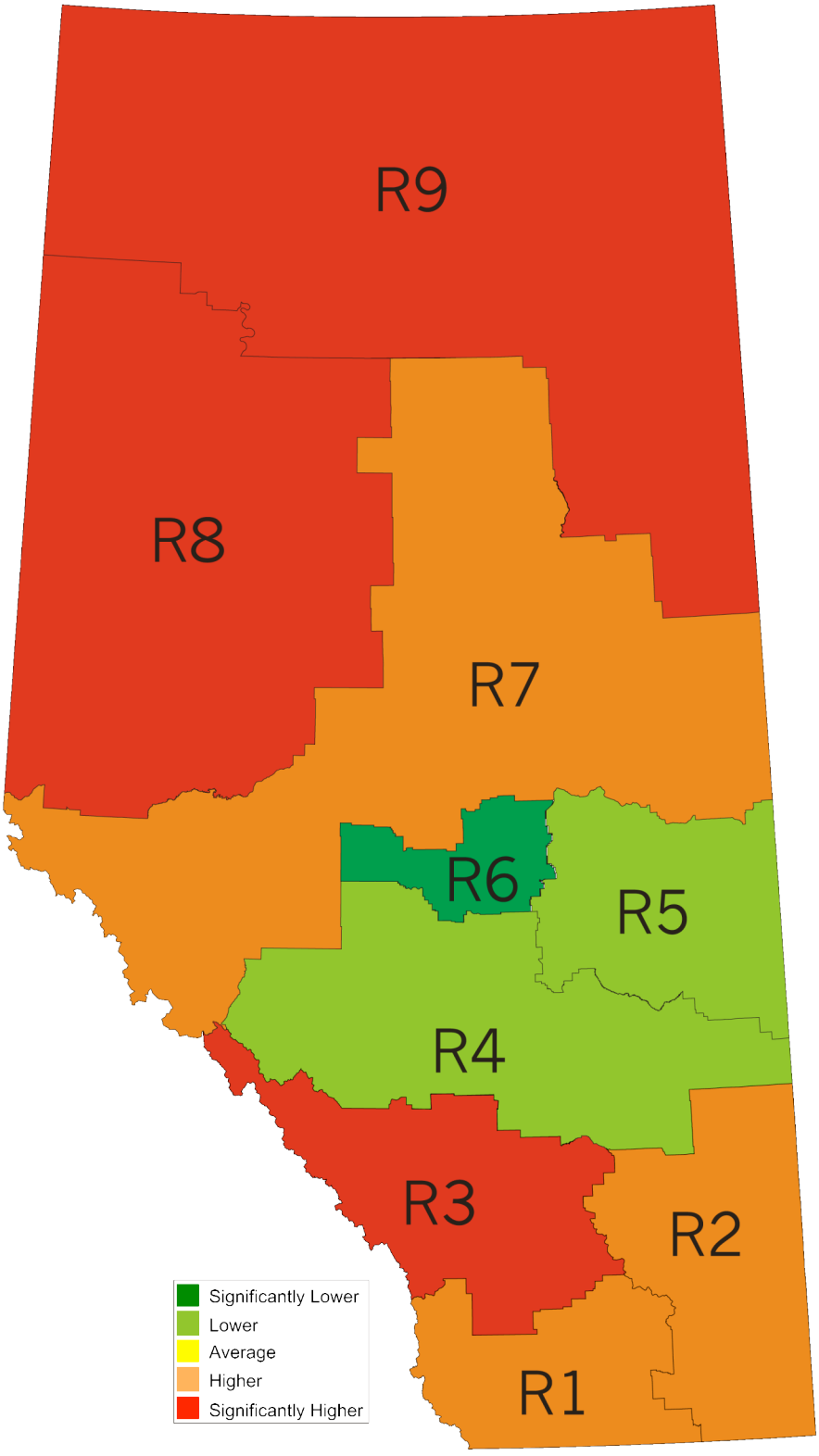
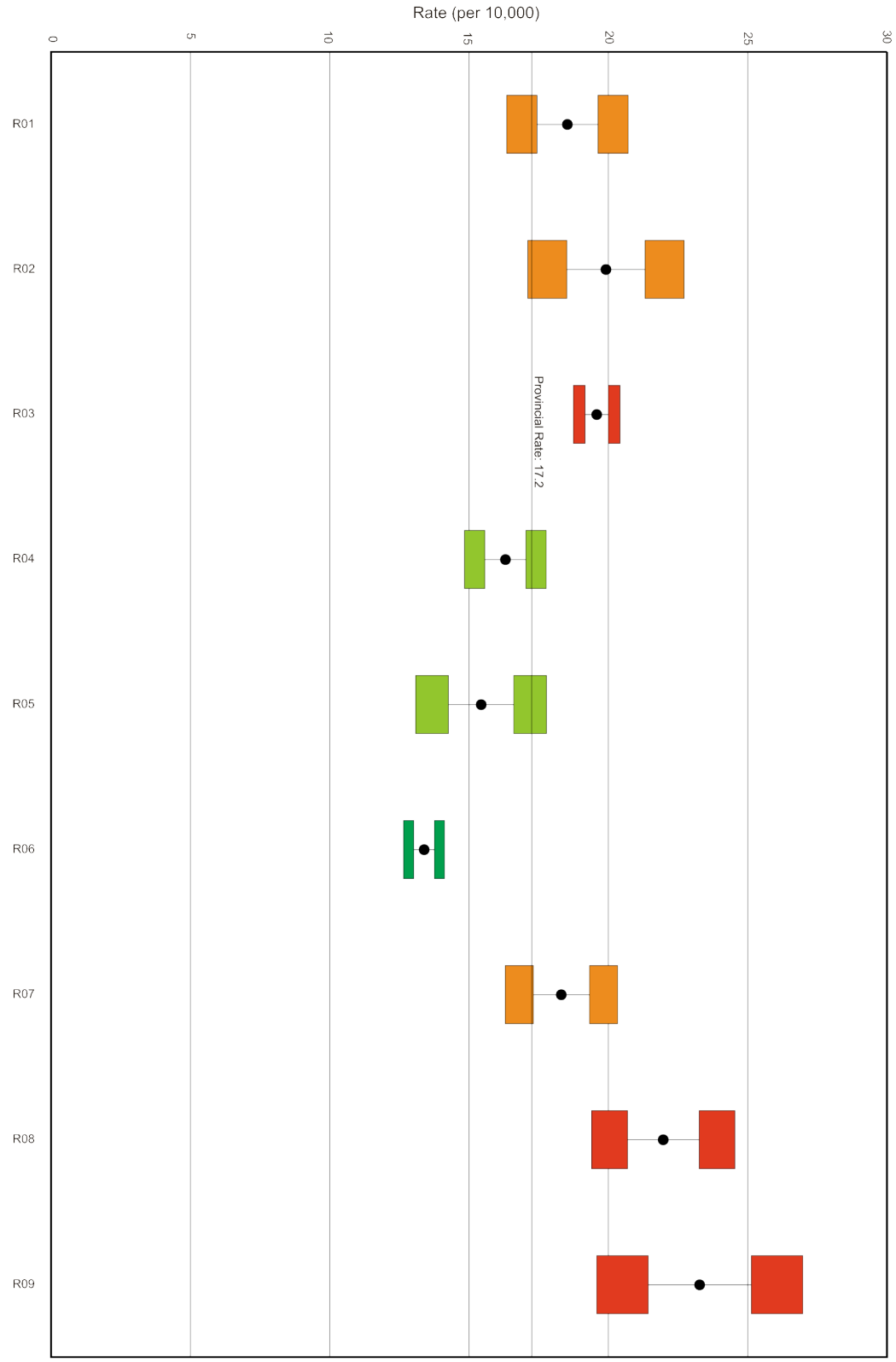


Figure 22: All congenital anomalies RHA graph



Heart Septal

The RHA-level map shows that the rate for Heart Septal Congenital Anomalies is lowest in Regions R3, R4, and R6, and highest in Regions 8 and 2. An examination of the graph for this health event reveals that the Standard Error is quite large for Regions 1, 2, 5, 8, and 9. Low population in these regions and few reported cases are responsible for these larger standard errors.

A first glance examination of the subregional map reveals some similaries to the map portraying all congenital anomalies. Further analysis reveals that no cases were recorded in two subregions. An analysis of the graph reveals that the standard errors are unacceptably high for a number of subregions (which reported at least a single case). If the standard error is equal or greater than the provincial rate, the reported rate for the tile is meaningless, as there can be no faith in the recorded value. Any inferences about the data may also be questionable even if the standard error is below the provincial rate, but close to it. **As a result, the technique is not well suited to this, less common, health event.** By aggregating the data over several years (5 years, for example), the rates should be stabilized sufficiently to perform a proper analysis of this type of information.

It is essential to remember that patterns in a map cannot be examined separately from the data and graphs that are created form the same information. In this case, it is not appropriate to determine any patterns from the data as it now stands. The analysis should be performed at the RHA-level or several years of data should be aggregated together in order to ensure stable rates. Ideally, both would be done. Five individual years of data could be examined at the RHA-level to determine any temporal patterns, and then all five years of data would be aggregated and examined at the subregional level. With this information, it may also be possible to examine three years worth of data aggregated together with different starting years (i.e. 1995-1998, 1996-1999, and 1997-2000) to examine temporal consistency at the subregional level.

Figure 23: Heart septal anomalies subRHA map

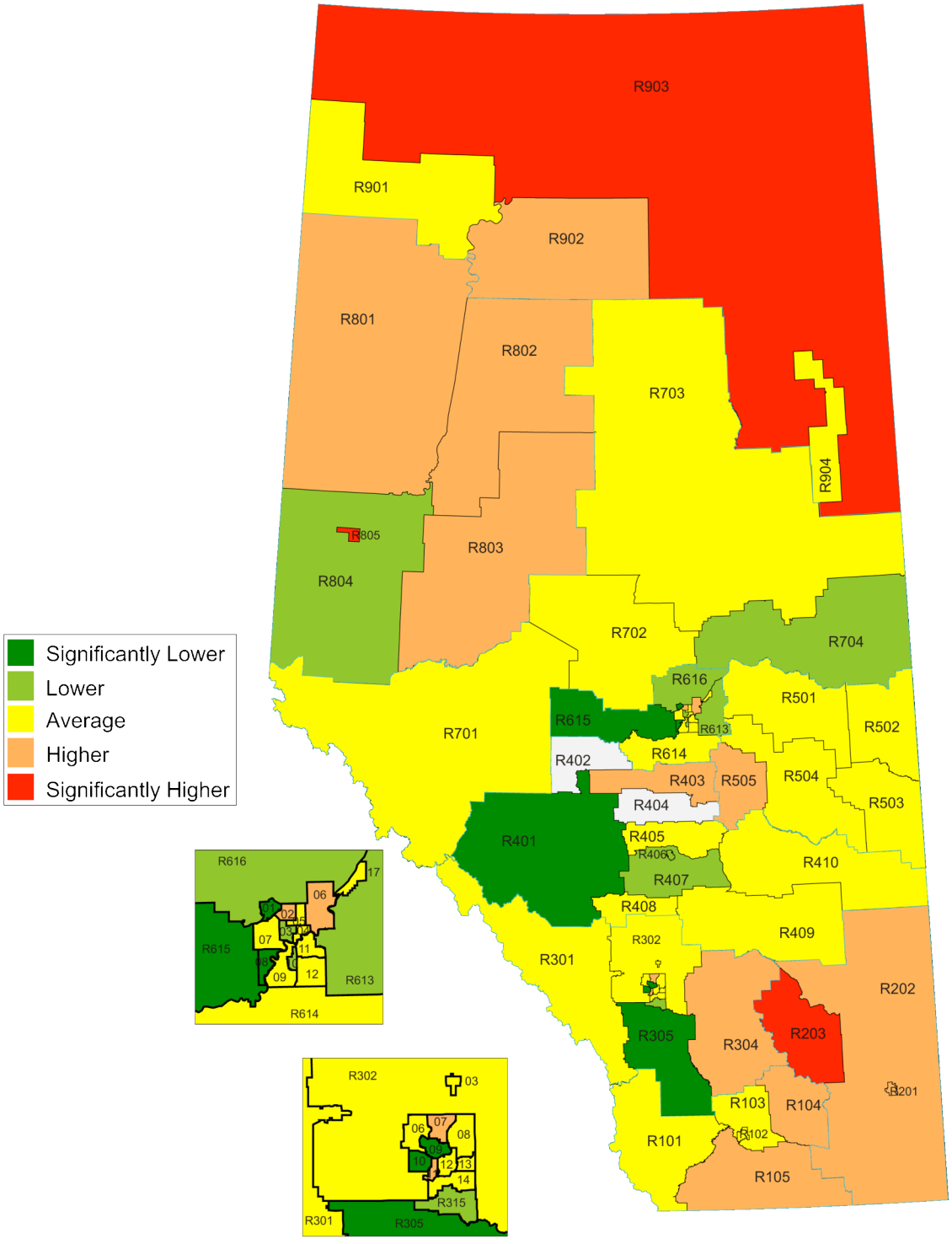


Figure 24: Heart septal anomalies subRHA graph

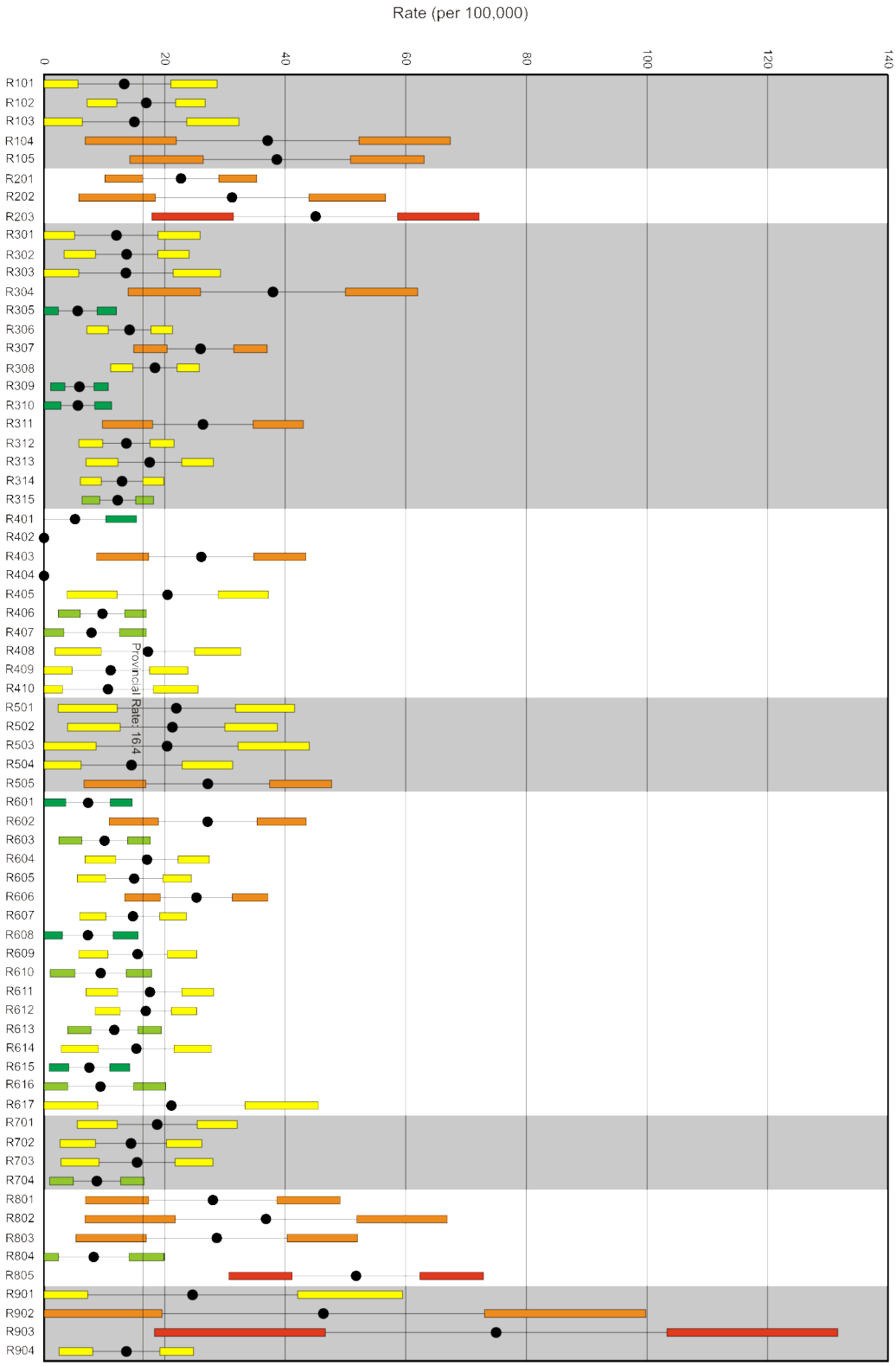


Figure 25: Heart septal anomalies RHA map

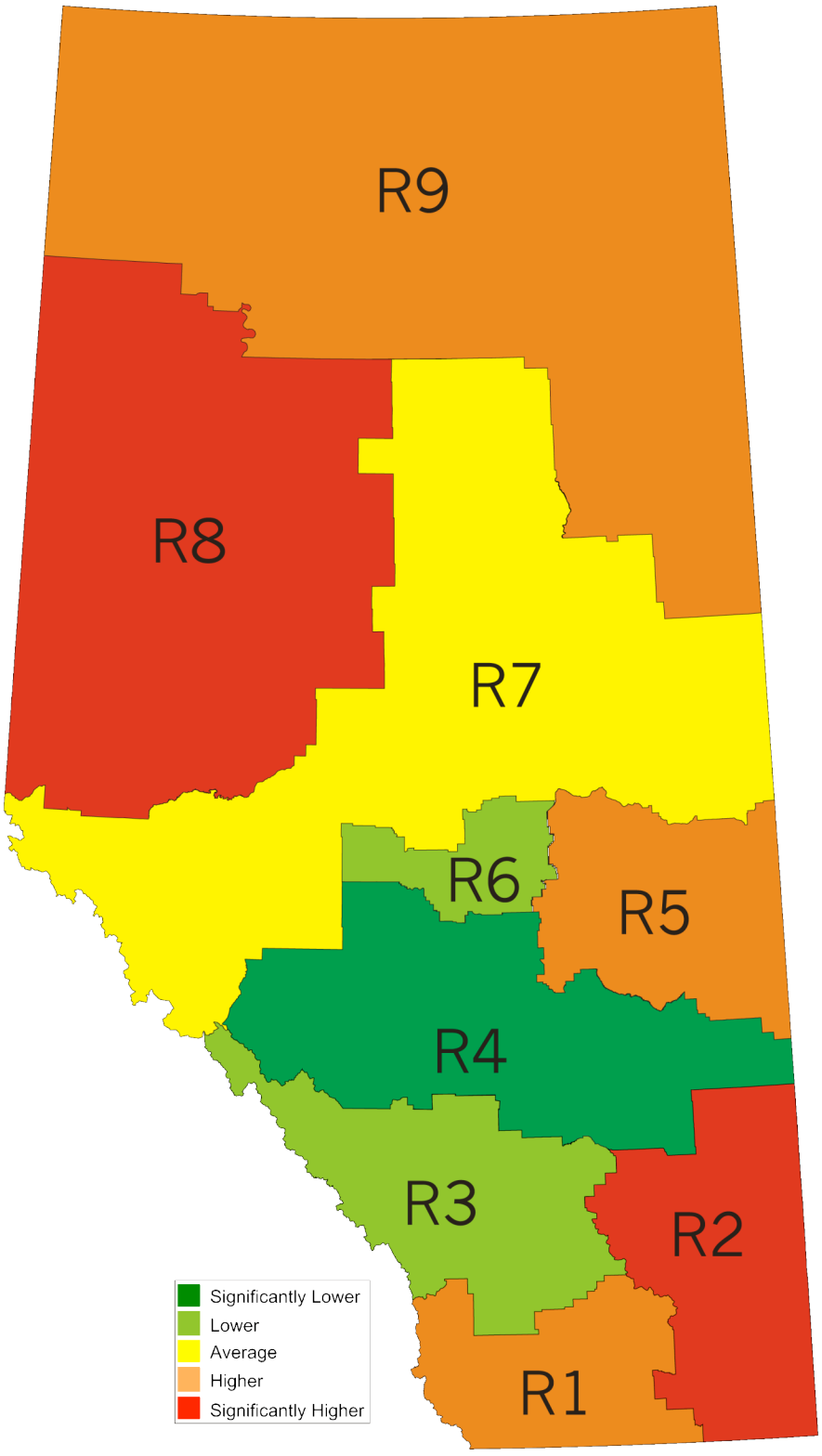
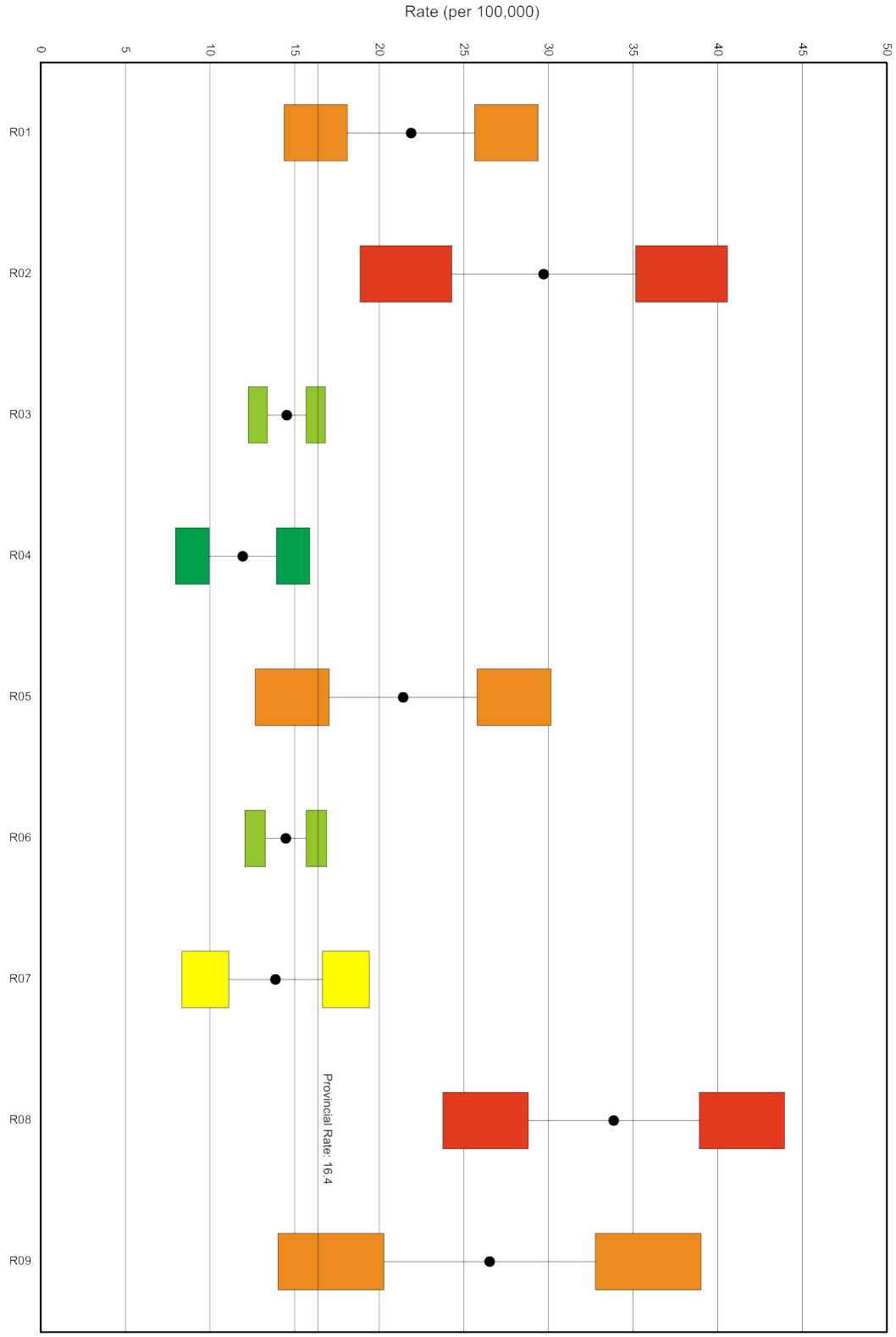


Figure 26: Heart septal anomalies RHA graph



Down's Syndrome and Cleft Palate/Lip

These two congenital anomalies are less common than Heart Septal defects, and thus this type of information should be aggregated over several years or should only be analyzed at the RHA level. Even at the RHA-level, several years' worth of data must be aggregated in order to offer any meaningful insight into the data.

Figure 27: Down's syndrome subRHA map

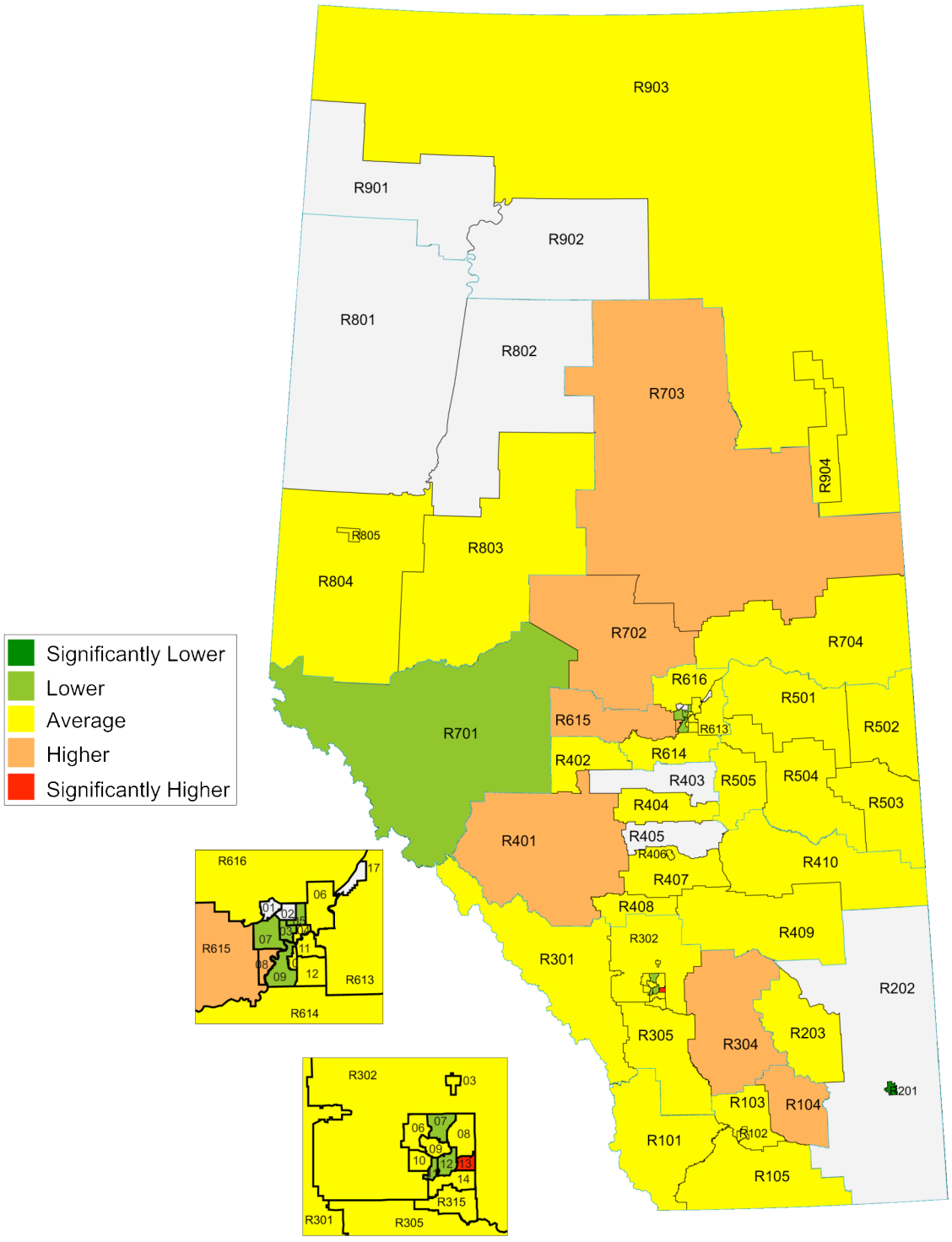


Figure 28: Down's syndrome subRHA graph

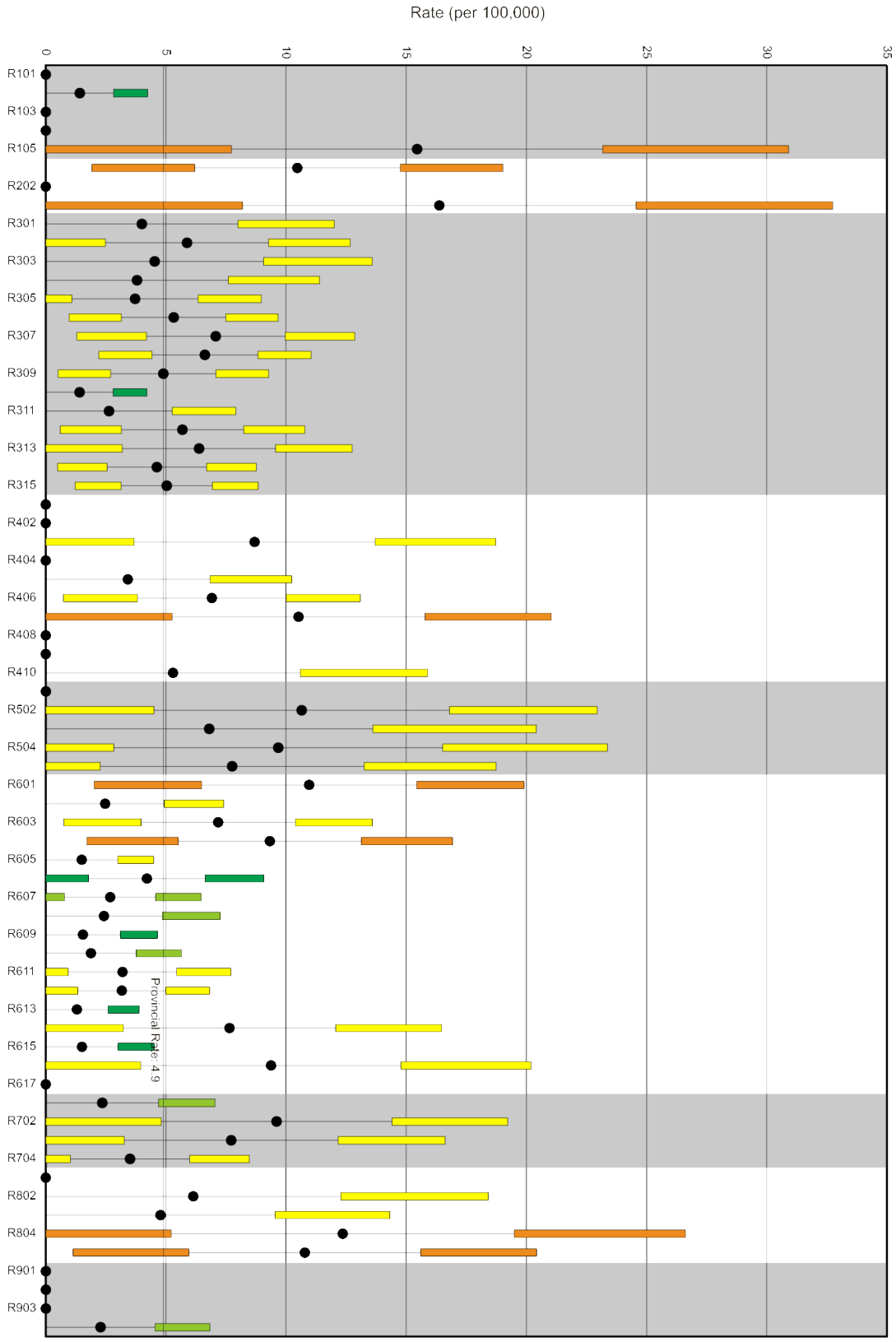


Figure 29: Down's syndrome RHA map

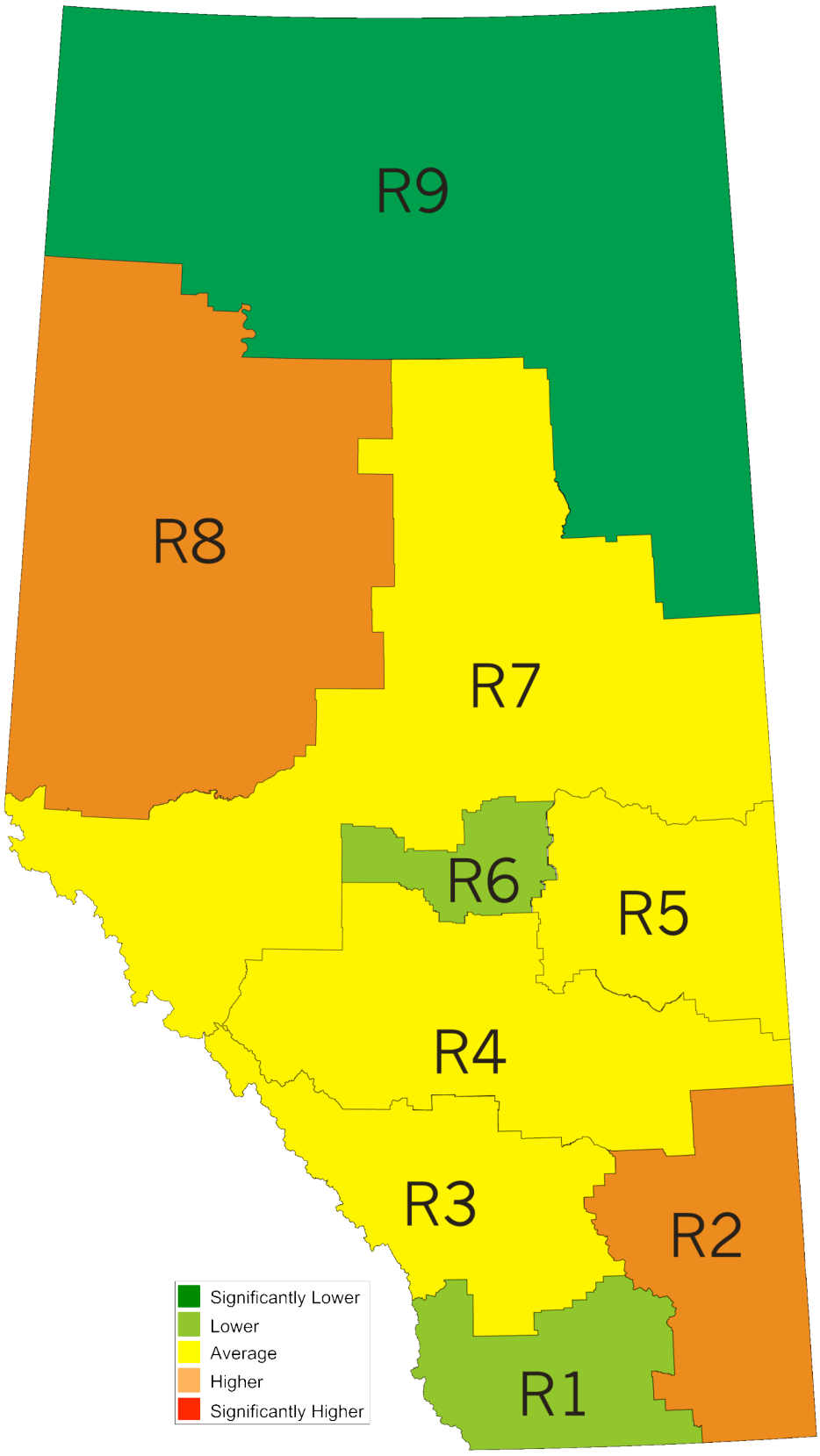


Figure 30: Down's syndrome RHA graph

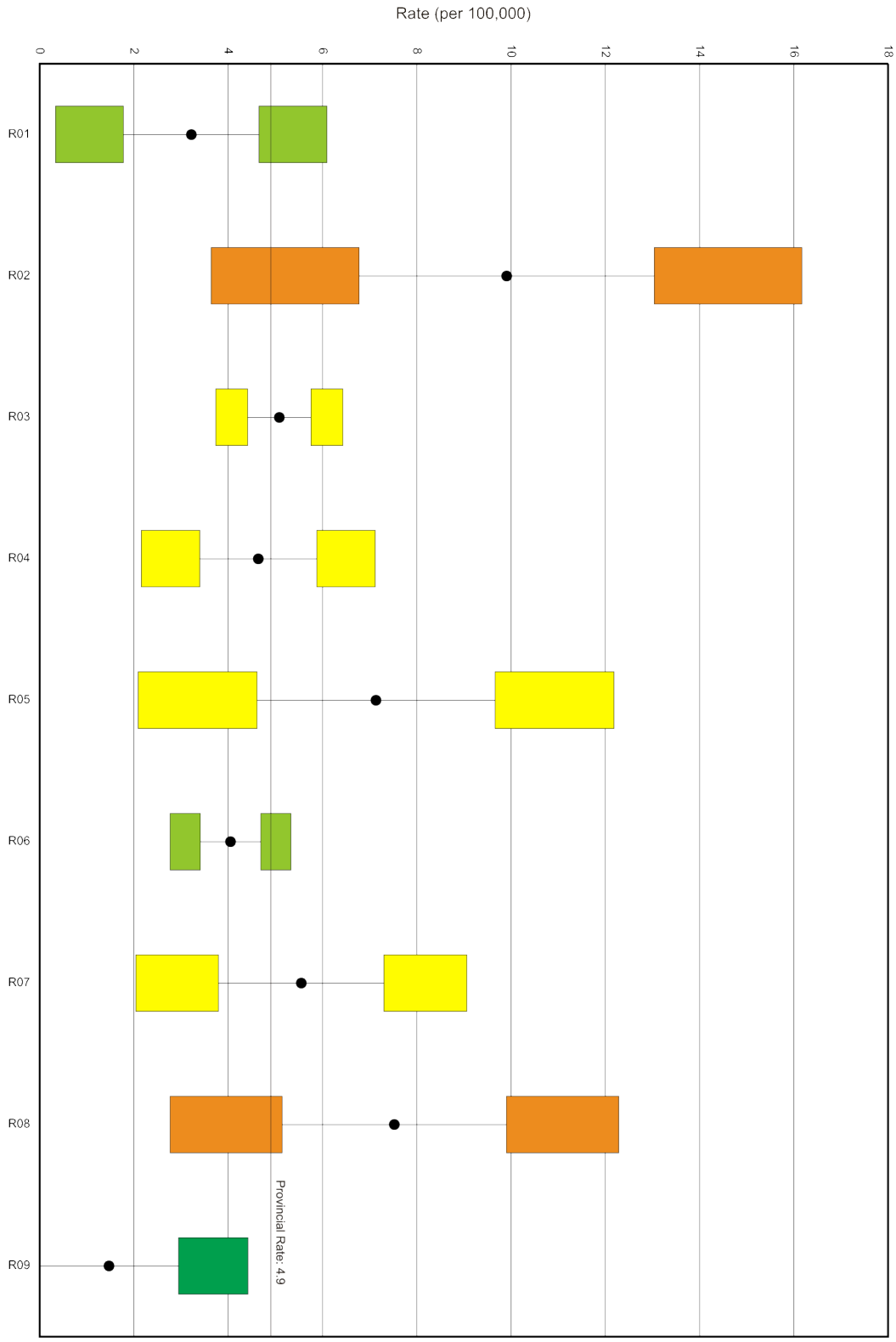


Figure 31: Cleft lip/palette subRHA map

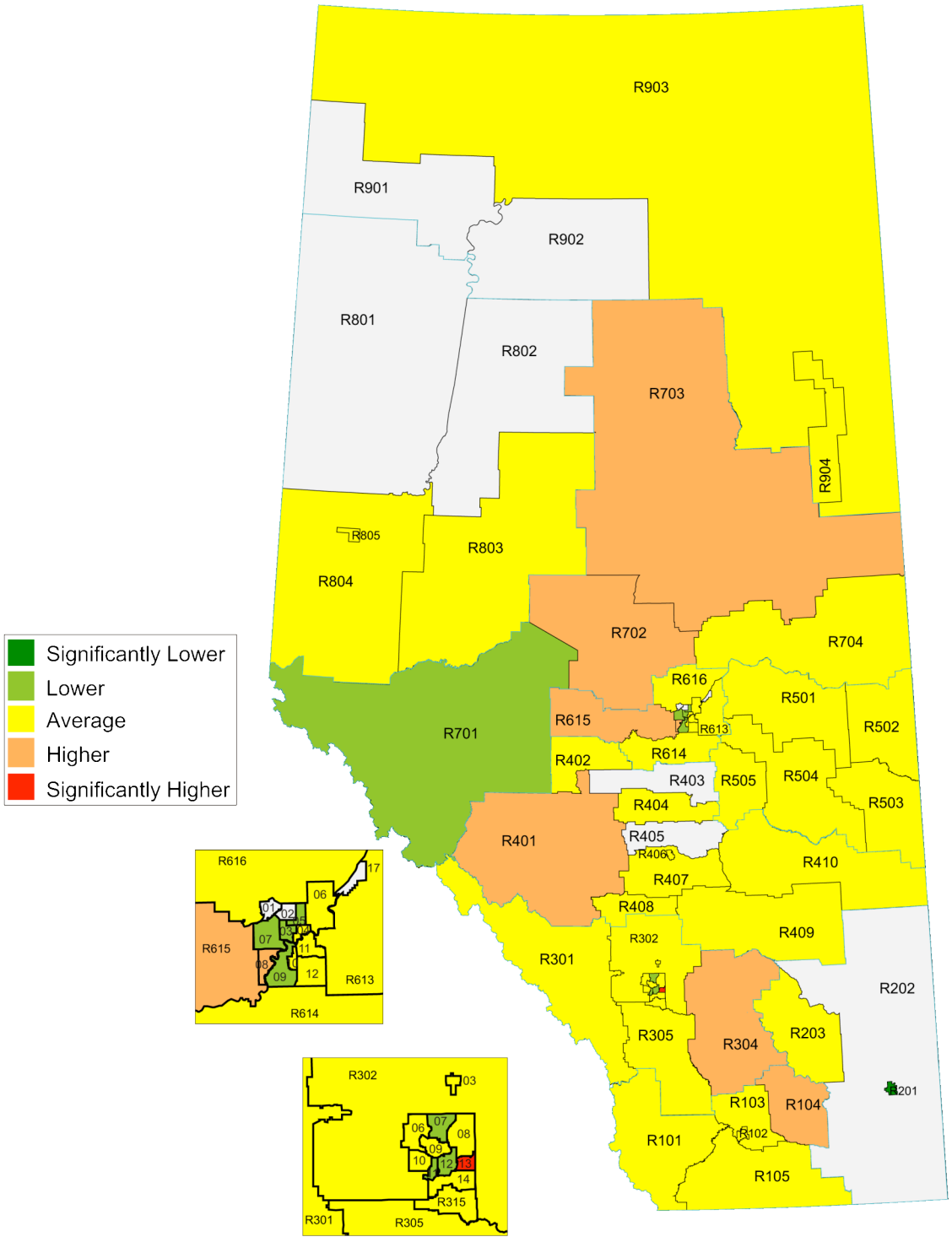


Figure 32: Cleft lip/palette subRHA graph

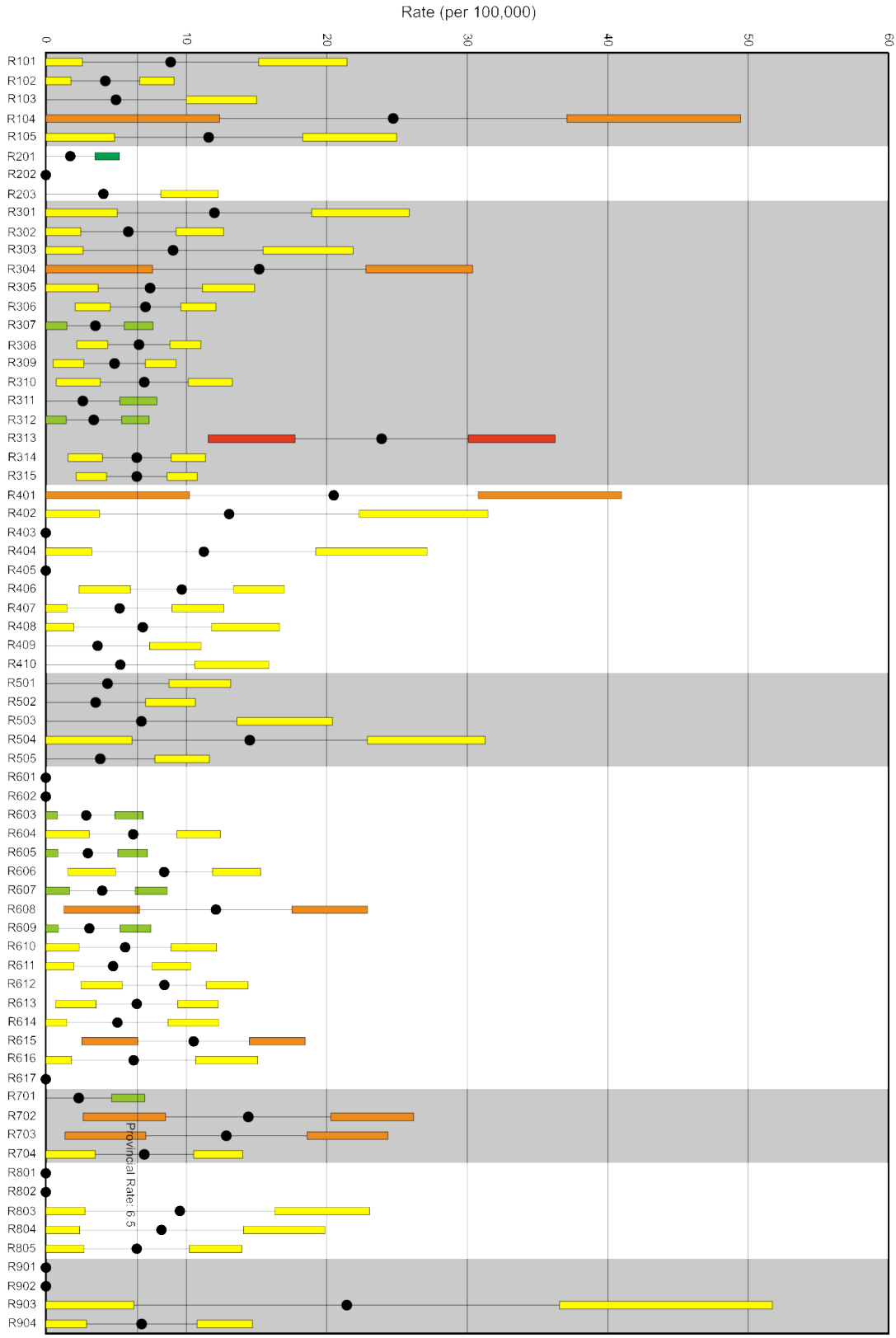


Figure 33: Cleft lip/palette RHA map

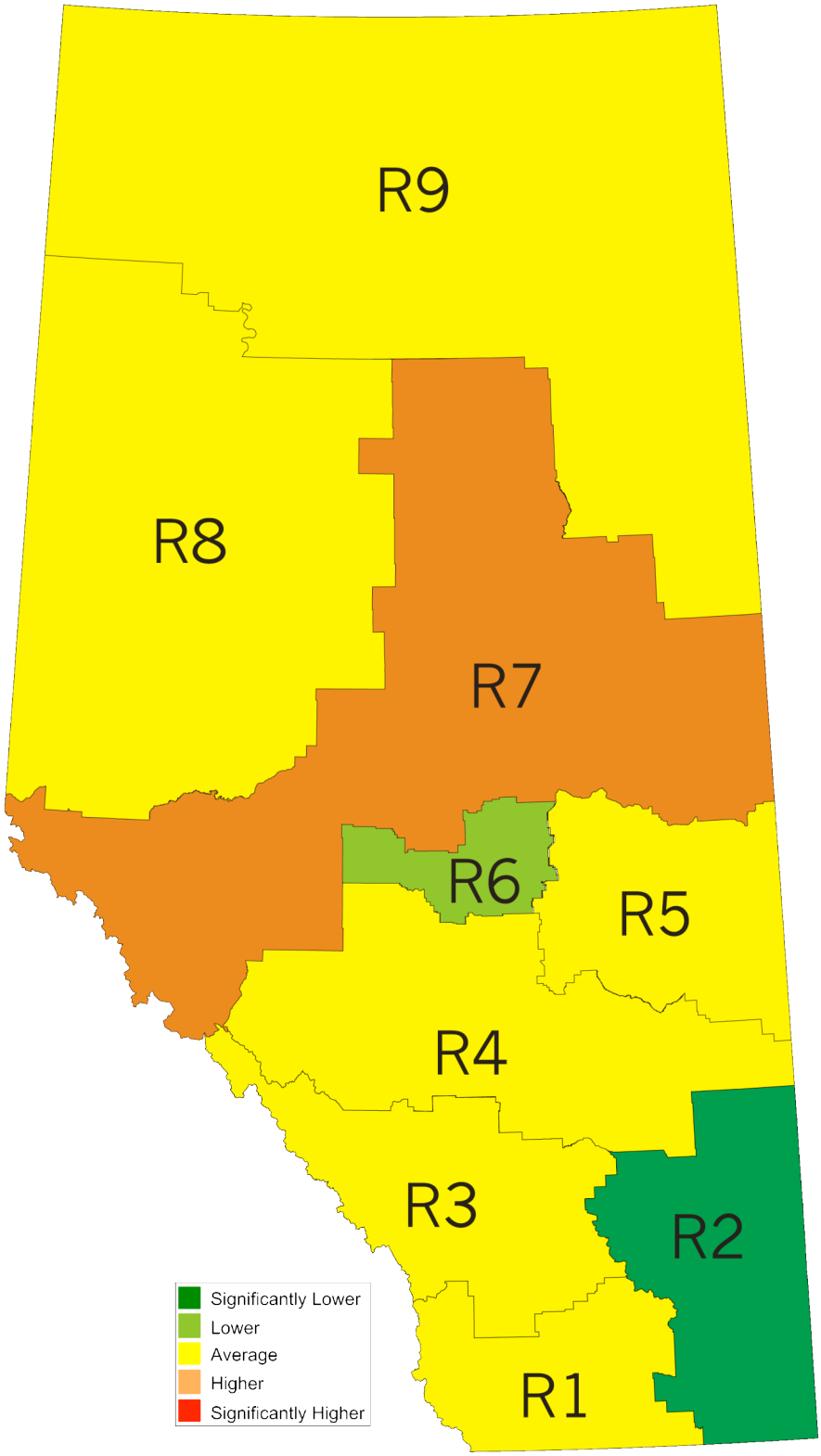
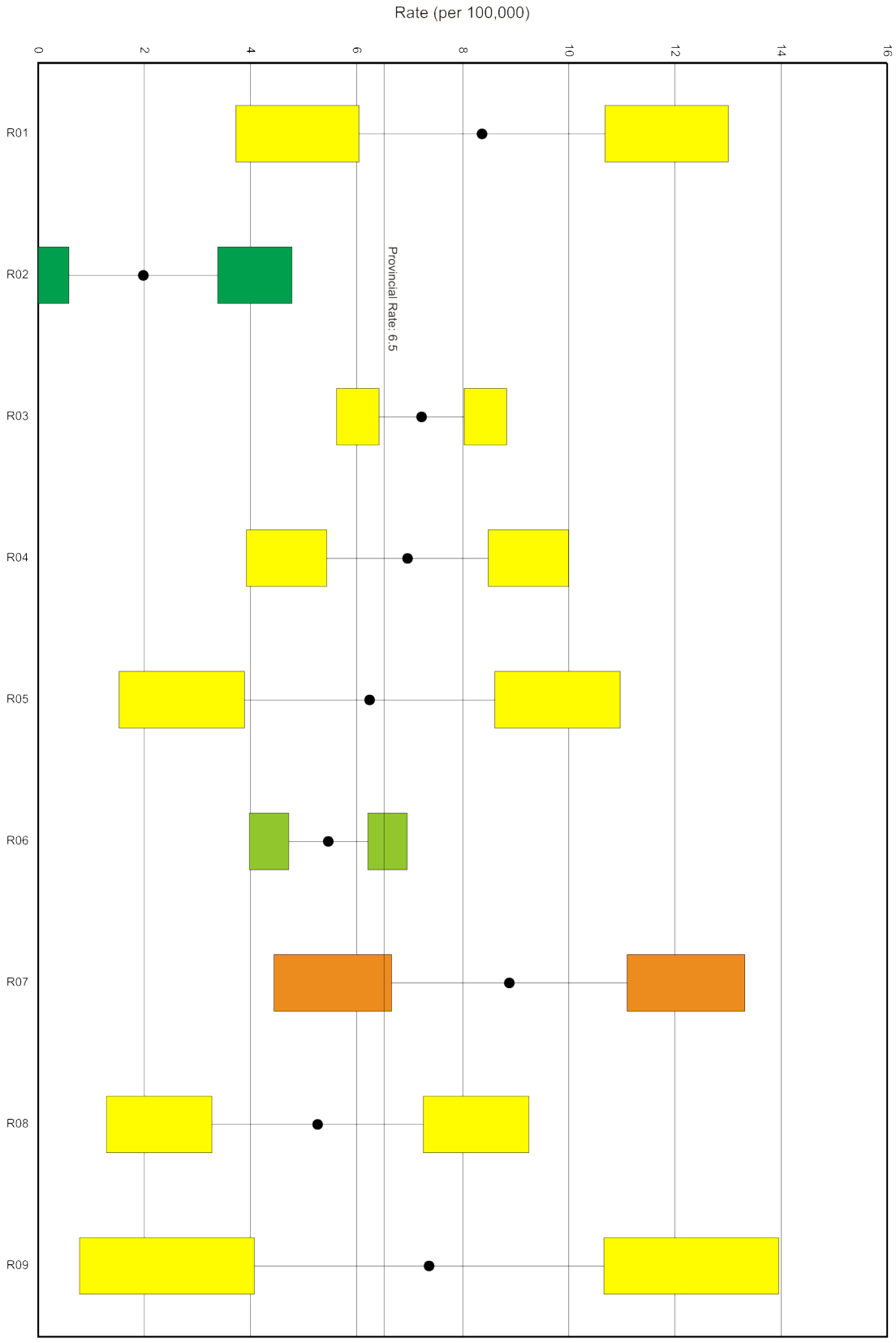


Figure 34: Cleft lip/palette RHA graph



Overall Patterns

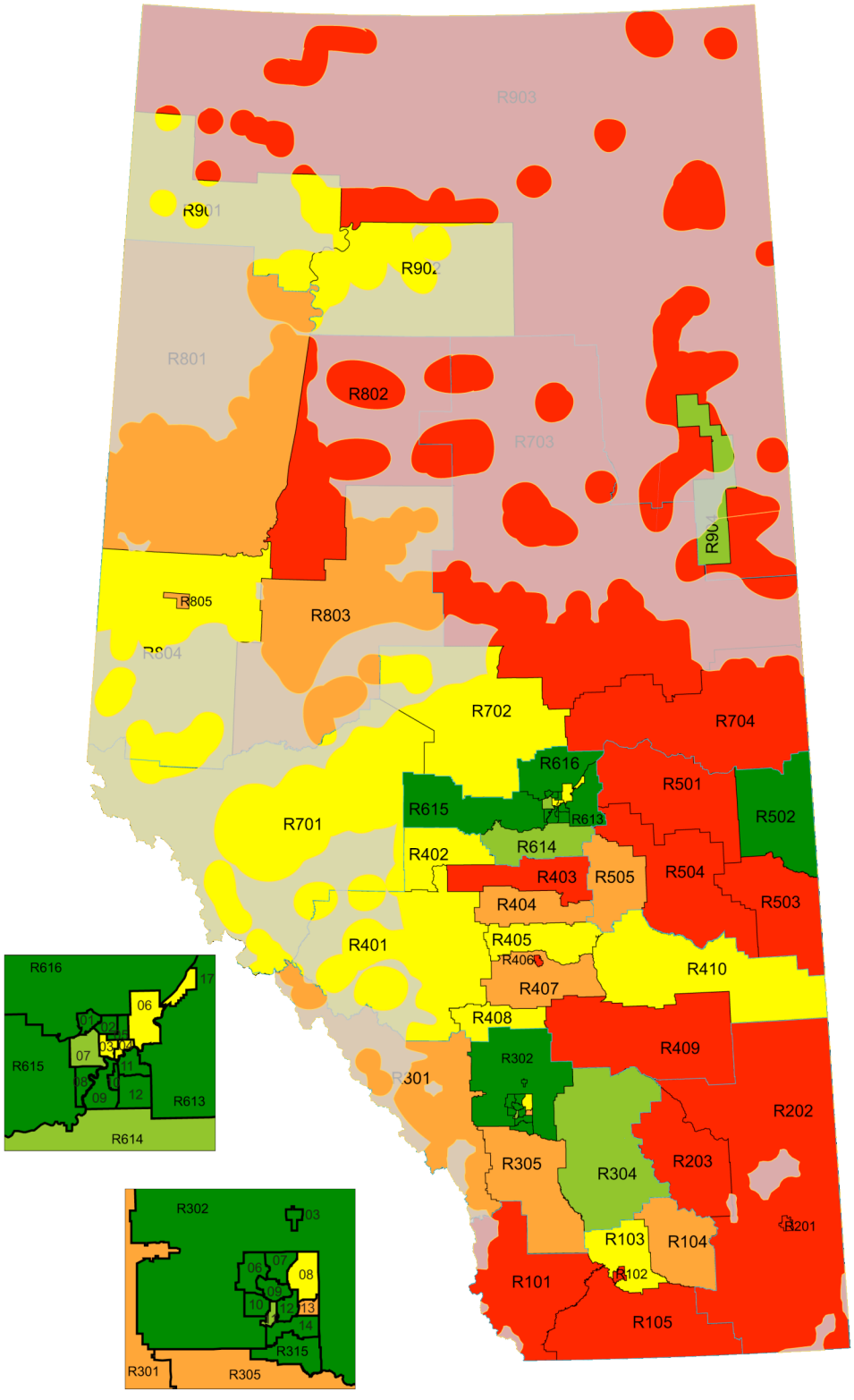
The analysis of health events listed above reveals that this technique is well suited to the spatial analysis of health events in the Province of Alberta. A number of patterns were revealed, which were not available at the RHA level. This technique should allow professionals to determine where certain issues are present in order to develop appropriate methods to improve the health of the population. A number of health issues that appear to have an urban or rural association when examined at the RHA level had more complex distributions. Since these subregions nest into the RHA boundaries, they are very useful for the 9 regions to examine their data in order to form a better understanding of the spatial patterns within each region. The method also creates a scenario where cooperation between adjacent regions is more likely in order to address an issue on the shared boundary.

Care must be exercised when using this technique to analyze rare health events since this can create difficulties with large standard errors or empty cells. Several years of data must be aggregated in order to analyze the data at this level.

V. Masking and population density

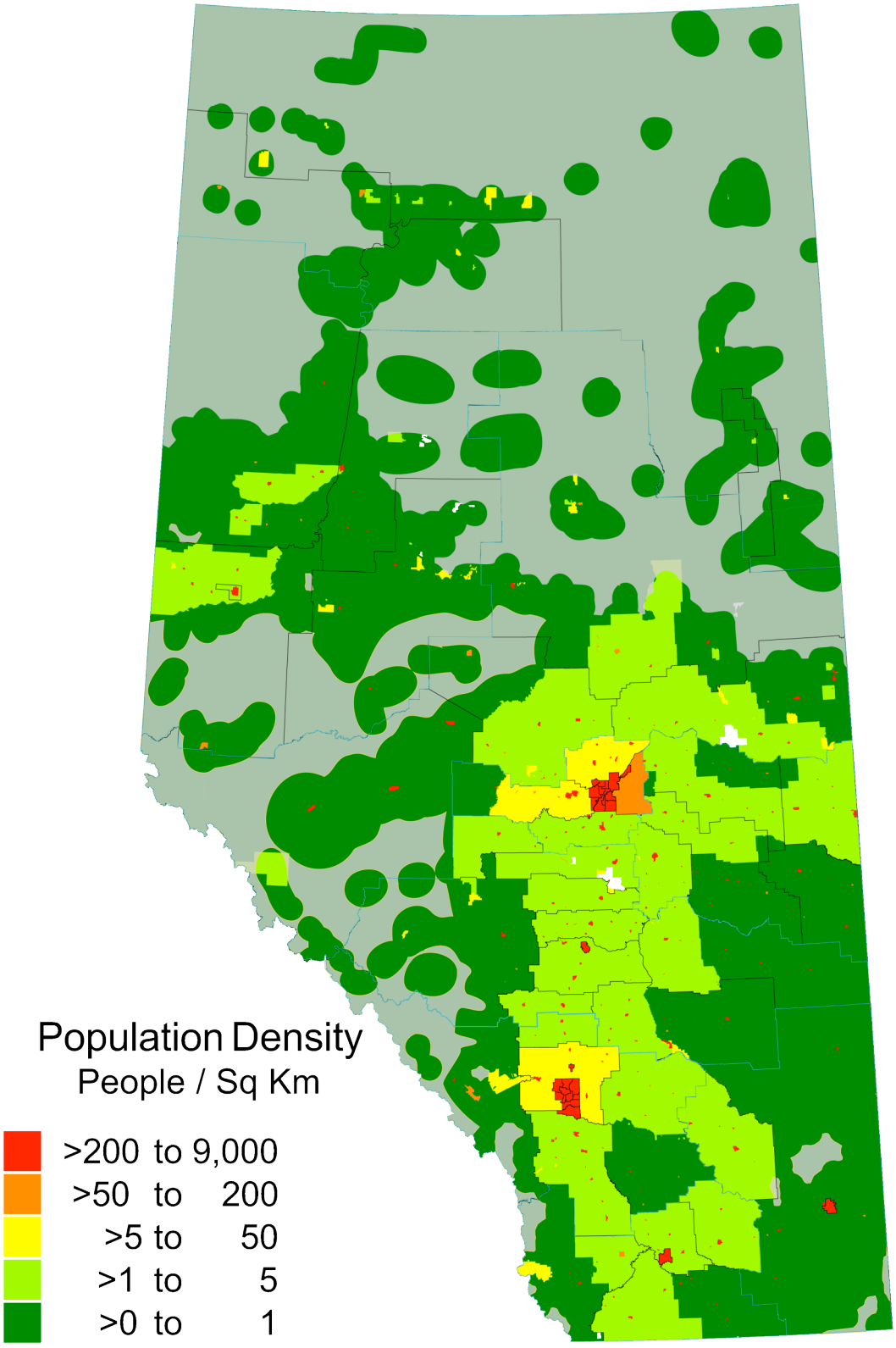
The undivided northern RHAs present a deceptive view of the data. The fact that they comprise large geographic regions provides the appearance of inconsistency in the methodology. Also, when 2 or more of these northern RHAs appear in red, they generate a serious visual impact that is not in keeping with the size of the population affected. In order to avoid this visual discrepancy, a populated areas mask was created. This mask was created using the populated townships data obtained from Statistics Canada (1996 Census population data aggregated to the township level). A buffer of 10-km radius was created around every point in order to create a map showing all the populated areas in the province. The inverse of the map was created to form a mask, where the unpopulated areas are covered with a white region to indicate that they are not populated. The results are presented in the map below:

Figure 35: Masked subRHA asthma map



Clearly, this map helps to explain why some of the northern subregions are so large: their population only covers certain portions of the region. In fact, Region 9 (Northern Lights) was subdivided into blocks of subregions of 5,000 people (instead of 15,000) in order to avoid having just two subregions (Ft McMurray region and the rest of the RHA). The question about the population density in these populated regions may naturally arise, so a population density map was created for the province. The map appears below:

Figure 36: Masked population density map



This map helps to interpret the information presented before. The map shows that the more northern populated areas are not only few, but also their population densities are also low. Despite the geographic size of these regions, their population is small and sparse. This highlights the challenge that these RHAs face in providing health services to the citizens of the RHA.

VI. Conclusion

The work described above demonstrates the benefit of examining health event data at a level lower than the RHA, while still using the RHA as a roll-up level. The health measures for a number of sub-RHAs varied dramatically from the overall RHA measure. In some cases there were differences between the rural and urban components of the RHA. Sub-RHAs that neighbour each other tend to be more similar to each other (even if they are in a different RHA) than sub-RHAs that are farther away from each other and within the same RHA. There are natural clusters of sub-RHAs in the province regardless of the pattern observed for the RHAs. This method provides more detail than RHAs, yet is consistent with RHA boundaries. They allow interpretation of health issues at a provincial level, and to some extent at the regional level.

The use of sub-RHAs for the analysis of health event data is recommended alongside RHA level analysis.

VII. Next Steps

Examination of other disease categories

The data used for the analysis of health events included in this report were derived from morbidity and congenital anomalies sources. It would be useful to determine the suitability of the sub-RHAs to other health event data such as physician claims, mortality, census, etc.

Refinement and Automation of subregional mapping capacity

The sub-RHA maps created in this report were produced by a mostly manual method of spreadsheets and GIS, while the RHA-level maps were created using an automated template in MS Excel as described in a separate report in this series. A similar template will be made available to allow anyone who has access to MS Excel to create sub-RHA maps, cartograms, and graphs that show the sub-RHA rate and standard error against the provincial rate for the same health event. The postal code lookup file will also be made widely available to ensure consistency in the determination of postal code membership to each RHA. Proper documentation will accompany these information products to allow a range of individuals to perform sub-RHA analysis with little or no training.

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Ellehoj, E.A., Wilson, S, et al (2005). *Definition of Rural and Urban Areas for Health Services Provision-Geographic Methodology Series (in preparation).*

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Health Trends in Alberta, 2001. Alberta Health Surveillance, Alberta Health and Wellness. ISSN 1480-6657

Appendix: Subregional maps and municipal boundaries

The maps that appear in this section illustrate in more detail the boundaries of the subRHAs that appear in figure 1.

Figure 37: Subregional boundaries for RHA 1

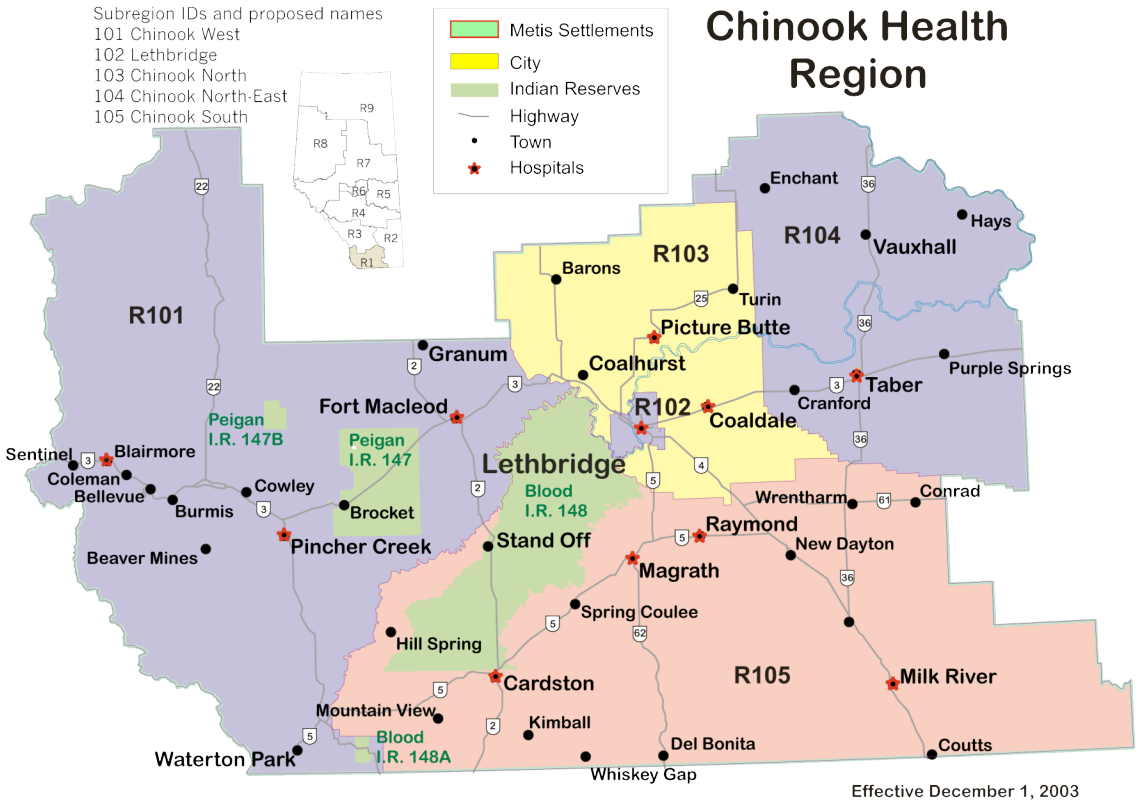

Figure 38: Subregional boundaries for RHA 2

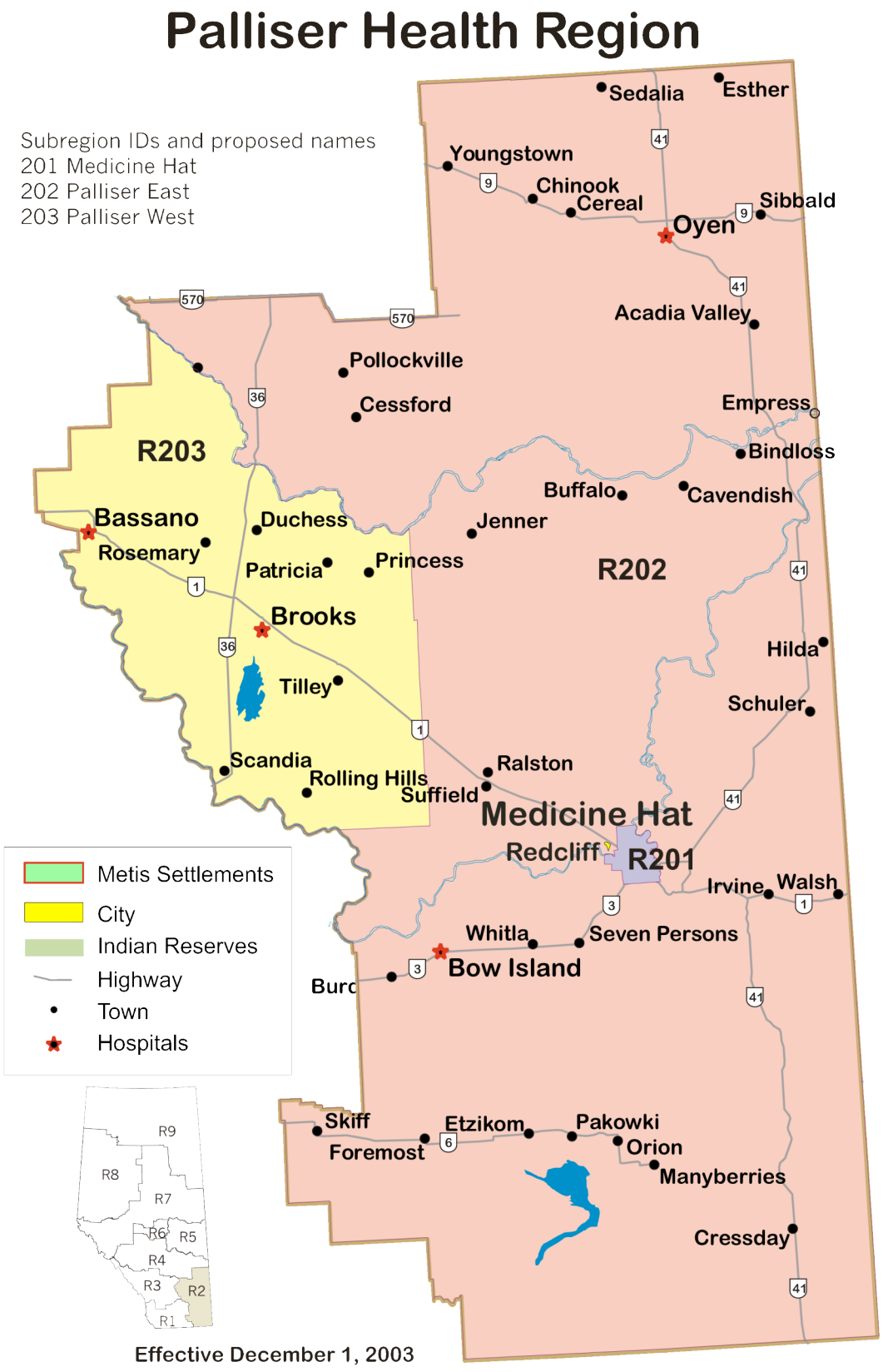

Figure 39: Subregional boundaries for RHA 3

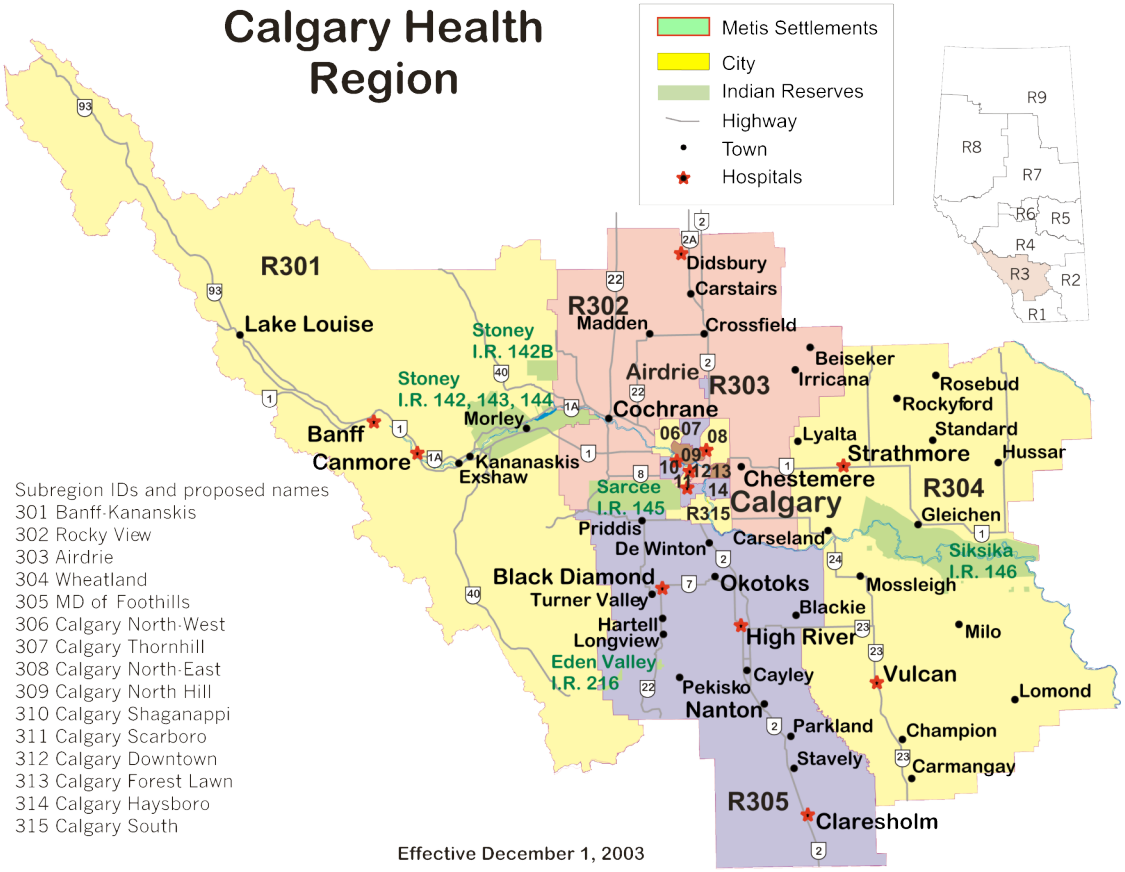

Figure 40: Subregional boundaries for RHA 4

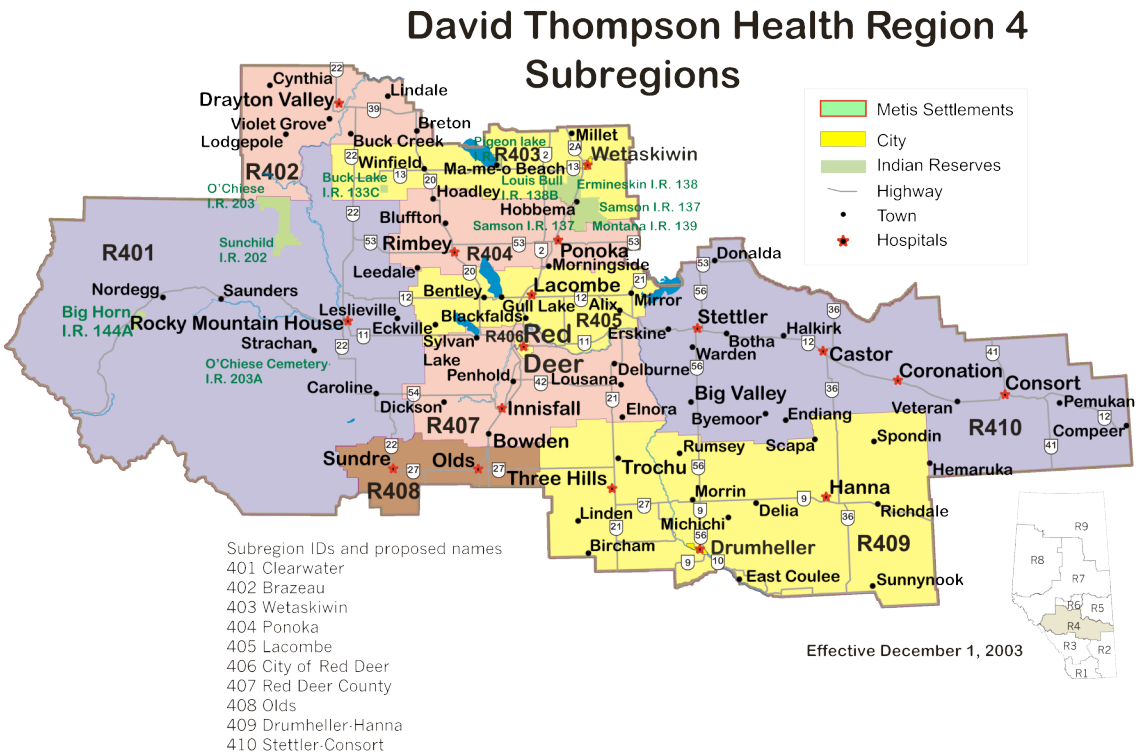

Figure 41: Subregional boundaries for RHA 5

Figure 42: Subregional boundaries for RHA 6

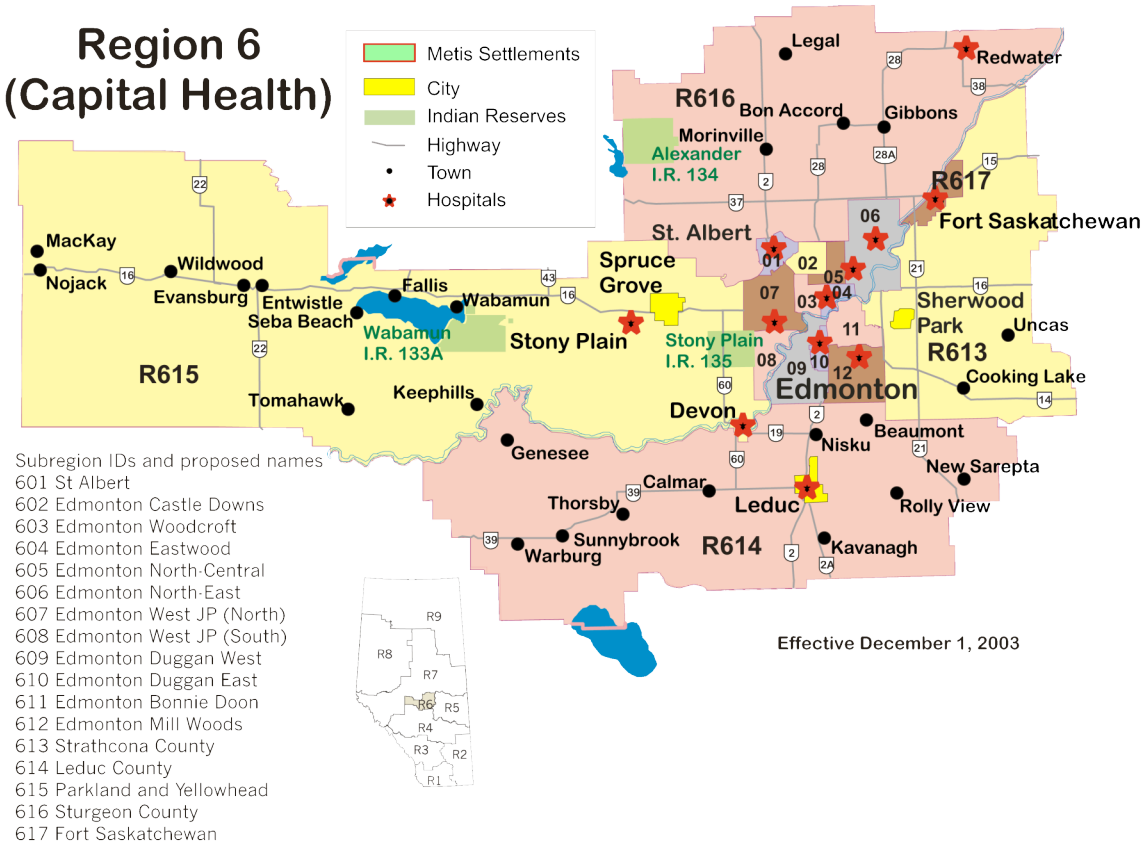

Figure 43: Subregional boundaries for RHA 7

Figure 44: Subregional boundaries for RHA 8

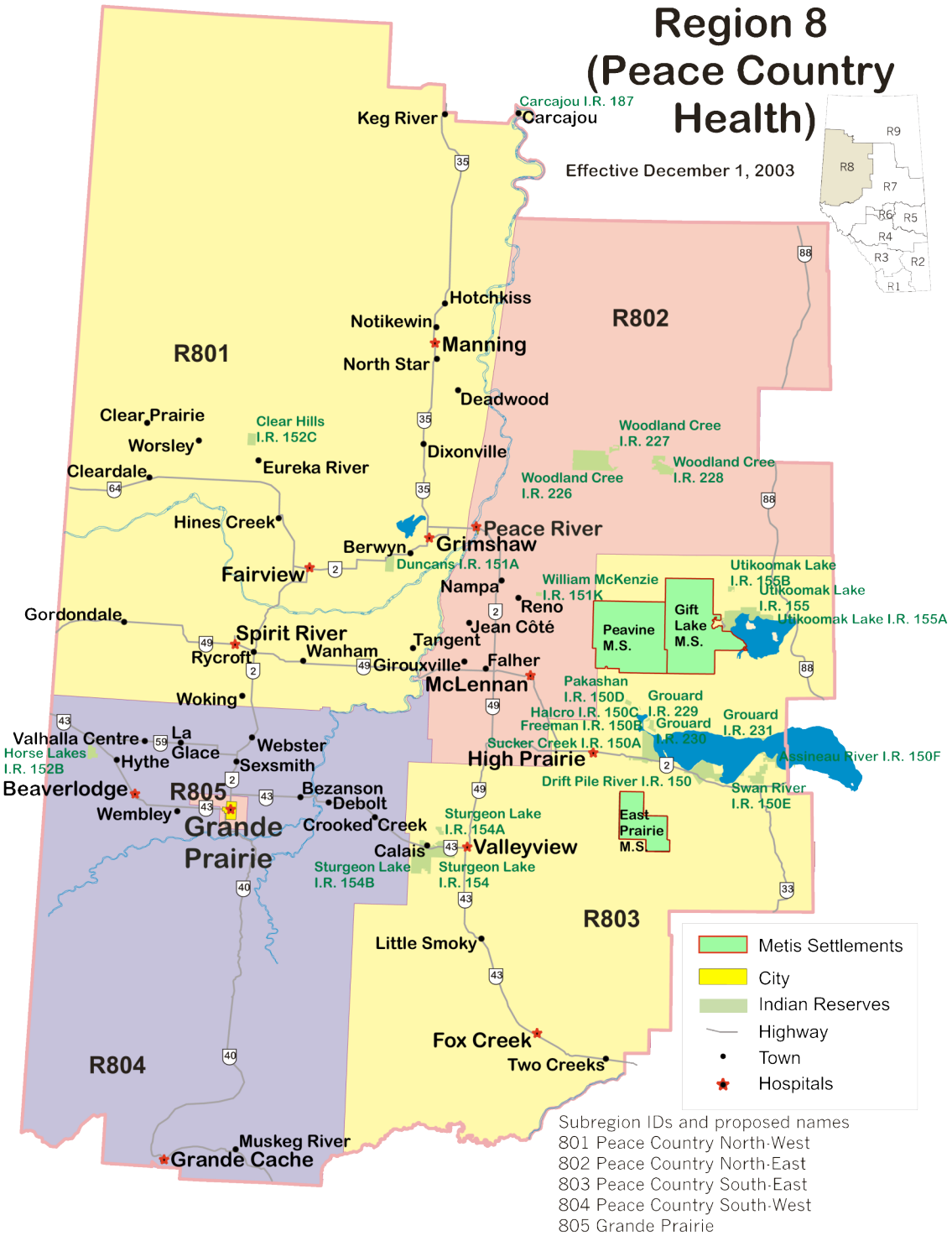

Figure 45: Subregional boundaries for RHA 9