Mount Nansen Project
Pony Creek Biomontoring Assessment

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EXECUTIVE SUMMARY

EDI Environmental Dynamics Inc. (EDI) was retained by Assessment and Abandoned Mines (AAM) in 2008 to conduct benthic macroinvertebrate sampling at the Mount Nansen site. The study focused on assessing baseline conditions in Pony Creek using the Canadian Aquatic Biomonitoring Network (CABIN) field methodology. Two sites were assessed on Pony Creek, including one site upstream of recent mining activity (P2A) and one site downstream of a waste rock pile and old adit (P1A). The waste rock had been removed from the downstream location six weeks prior to sampling.

EDI was again retained by AAM in 2011 to analyze the Pony Creek data using the CABIN database and assessment model. The Yukon Model developed for CABIN was used to compare data from the two Pony Creek test sites to data from a reference site group. Test sites were assessed based on a 90% confidence interval to determine if there were statistical differences in the benthic communities compared to reference sites. If the benthic community at a test site does not resemble the range of its predicted reference communities, this indicates there has been some impairment.

During the model building step, both Pony Creek test sites were assigned to Reference Group 1; however, probabilities of belonging to other reference groups were also high. Total abundance and taxa richness at the Pony Creek test sites was lower compared to reference site means, but this may be attributed to the small size of Pony Creek compared to the reference sites as well as potential increased invertebrate drift due to high water levels in 2008. Furthermore, the CABIN test site assessment determined that the Pony Creek upstream site (P2A), which has not been affected by recent mining activity was 'stressed', while the downstream, recent mine-impacted area was 'potentially stressed'.

It is important to note that the total number of invertebrates from each sample was noticeably low, as a taxa count of at least 300 is typically desirable for biomonitoring studies. This may ultimately affect the CABIN model's ability to provide conclusive results, and some discretion is required when interpreting the test assessment results. The CABIN test results should be considered in conjunction with additional information available, including composition and ecology of the biota present, their tolerance or sensitivity to pollution, and the habitat condition and water quality at the test sites.

Diptera and Plecoptera were the most dominant taxa in both samples and overall taxa abundance and richness was higher at the downstream site compared to the upstream site. The differences are likely attributed to the habitat, as the downstream site has larger sized substrate which provides a greater variety of microhabitats and cover from predators and high flows. In terms of water quality, both sites were well-oxygenated, had neutral pH and specific conductivity within the normal range; however, metal concentrations were elevated at the downstream site, likely attributed to the waste rock pile that used to be located in the area, which may have led to the 'potentially stressed' assessment result.

Regardless of high metal concentrations at the downstream site, there was a greater abundance of Plecoptera at this site, which are considered sensitive to disturbance. The composition of Plecoptera in both samples has also increased from previous monitoring on Pony Creek from 1997. Also during the 1997 benthic

study, the sample was dominated by pollution-tolerant invertebrates and indicators of poor water quality. The absence of these types of organisms in the 2008 samples is a potential indicator that conditions may have improved over the years. Additional studies may be warranted to further assess the condition of Pony Creek and to confirm whether conditions have continued to improve since 2008.

ACKNOWLEDGEMENTS

EDI would like to thank the AAM staff who provided edits and comments during the draft stage of this report. Special thanks also to Stephanie Strachan at Environment Canada who assisted with CABIN project setup and model input interpretation.

AUTHORSHIP

This report was prepared by EDI Environmental Dynamics Inc. The EDI staff who contributed to this project include:

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Field work in 2008 was completed by Lyndsay Doetzel and Meghan Marjanovic.

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1 INTRODUCTION

EDI Environmental Dynamics Inc. (EDI) was retained by the Yukon Government Assessment and Abandoned Mines Branch (AAM) in 2008 to conduct benthic macroinvertebrate sampling at the Mount Nansen site. The study focused on assessing baseline conditions in Pony Creek, a small tributary that had not been sampled since 1997. The results are intended to be used as a basis for future comparisons to determine the success of remediation of the Mount Nansen site.

The 2008 study was undertaken according to the Canadian Aquatic Biomonitoring Network (CABIN) program methods; however, the contract did not include entering the data into the CABIN database or inputting it into the Yukon assessment model to assess the potential level of impairment of Pony Creek. Instead a quantitative study was completed to describe community composition through calculations of relative abundance and diversity indices.

EDI was retained again by AAM in 2011 to enter the Pony Creek data into the CABIN database and assessment model. This report describes the methods involved, as well as interpretation of the results, and their application to the remediation of the mine site.

The 2008 field program report, *Benthic Invertebrate Communities at the Mt. Nansen Mine Site, Pony Creek* (EDI 2009), will be referenced throughout this report. For additional details on field methods and general results refer directly to EDI (2009). The following sections provide contextual background on the CABIN program and the Mount Nansen study area.

1.1 CABIN BACKGROUND

Environment Canada developed the CABIN program to provide a standardized approach to aquatic biomonitoring across Canada. The purpose of aquatic biomonitoring is to systematically evaluate changes in the environment using the benthic invertebrate community as an indicator. Monitoring of benthic invertebrates provides a time-integrated look at watercourse conditions rather than the snap-shot view provided by chemical and physical water sampling and analyses. Benthic invertebrates are ubiquitous, abundant and easy to collect due to their sedentary and relatively long-lived nature. As sedentary, bottom-dwelling and detritus-feeding aquatic organisms, benthic invertebrates sustain exposure to stream water and sediments throughout their life cycle. Some species of invertebrates are known to be intolerant to elevated concentrations of metals often associated with mining activity, while other, more tolerant species become more dominant in contaminated sites (Maret *et al.* 2003).

The CABIN program uses a Reference Condition Approach (RCA); comparing data from reference sites to data from test sites to determine whether or not there are statistical differences based on 90% confidence intervals. Reference sites are considered to be within areas minimally affected by human activities and represent the 'desired' or 'expected' condition for an area, while test sites are those that are within an area of suspected impairment due to human activities.

The online CABIN database houses reference data from sites across Canada. Training in the CABIN program is a requirement for field collection, study design, data entry and analysis. Environment Canada offers training in the CABIN program through a partnership with the Canadian Rivers Institute at the University of New Brunswick.

1.2 STUDY AREA

The Mount Nansen site is located approximately 45 kilometres west of Carmacks, Yukon. The site lies within the Victoria Creek watershed, which is a tributary stream to the Nisling River, a medium sized river in the Donjek/White Rivers drainage basin. Two small streams drain the majority of the mine footprint. The primary drainage is Dome Creek which flows from above the mill site, past the tailings facilities into Victoria Creek. Pony Creek drains a small portion of the mine site north of the Brown-McDade Pit and eventually flows into Back Creek, which is a tributary to Victoria Creek.

The Pony Creek area is surrounded by historical mining disturbance, including trenching, exploration roads, waste rock piles, earth berms, gravel quarries, an old adit, and core shacks.

2 METHODS

The Mount Nansen Pony Creek Biomonitoring Assessment was completed according to CABIN protocols. The project involved two phases: the field component completed in 2008 and the data entry and analysis component completed in 2011-2012. All components were completed by EDI staff trained in the CABIN program. The field component is described in greater detail in EDI (2009); however, a basic summary of field methods are provided below in Section 2.1, followed by the CABIN input methods, Section 2.2.

2.1 FIELD COMPONENT

Field sampling took place in the fall of 2008 at two sites, and closely followed the field procedures outlined in the CABIN Field Manual (Reynoldson *et al.* 2003). Specific methods are described in more detail in EDI (2009). In general, sampling involved collection of one kick-net sample at each site with samples being preserved in 70% ethanol prior to identification. Additional data was collected to characterize the habitat, including stream velocities, water quality parameters, substrate dimensions and riparian conditions.

Benthic invertebrate samples were identified to the family level by staff at the EDI lab in Prince George, BC using Merritt *et al.* (2008) and Clifford (1991). Subsampling using a Marchant Box was not required, as no sample had sufficient numbers of organisms to warrant subsampling at either of the two sites.

2.1.1 Sampling Sites

Sampling locations were established at two sites on Pony Creek (Figure 1) to capture variability within the stream. One site was located downstream of the adit and waste rock pile location (Site P1A; 08V 0389166, 6881723), and has been heavily affected by past mining activity. Beginning with mining activities in the late 1960s, and carried on in the 1990s, mine waste rock was deposited directly on top of Pony Creek at the downstream location, and subsequently, the creek flowed under and through this waste rock pile. The waste rock was removed in 2008, six weeks prior to the benthic sampling (EDI 2009). The area was then revegetated using live willow and poplar staking methods and grass seeding (EDI 2008a). A second sampling location was located upstream of the waste rock dump site (Site P2A; 08V 0388847, 6881823). This upstream site was largely unaffected by mining activities as it is not downstream of any tailings or waste materials; however, it does occur in an area where historic trenching has occurred.

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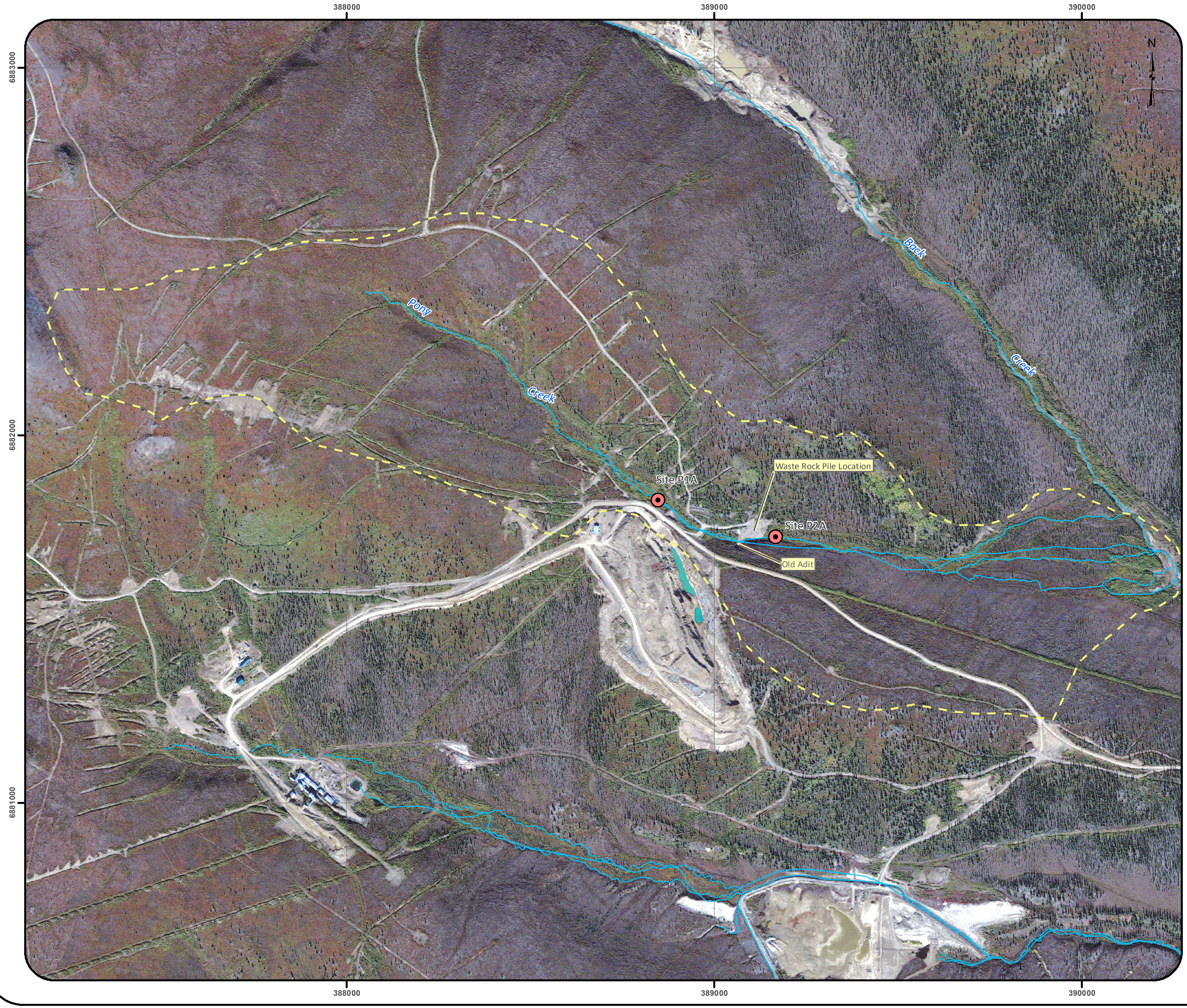

LEGEND

- Benthic Sampling Sites
- Watercourse
- Pony Creek Watershed

0 320,000 640,000 960,000 1,280,000
metres

Scale 1:10,500 (printed on 11x17)

MOUNT NANSEN

Pony Creek Biomonitoring Assessment Sites

Drawn: M. Marjanovic	Datum/Projection: NAD 1983 UTM Zone 8N
Checked: C. Mackay	EDI Project No.: 11-Y-0352
Date: 3/19/2012	Data Sources: Geomatics Yukon / AAM / EDI

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2.2 CABIN INPUT & STATISTICAL ANALYSIS

Prior to data input into the online CABIN system, the taxonomic classifications determined in 2008 were checked and verified in 2011. A project was set up within the CABIN database and benthic enumeration and habitat data was entered into the system. Note that benthic invertebrate counts were multiplied by a factor of 1.5 to account for the shorter two minute kick-net versus the standard three minute kick-net sample. Appendix A summarizes the data that was input into the CABIN database.

The CABIN program employs multivariate statistical analyses in a reference condition approach to biomonitoring. Through this approach, data from test sites (P1A and P2A) are compared to data from reference sites to assess if there are differences in the benthic community. A series of multivariate statistical techniques are used within the CABIN program to make the determination of whether or not there are statistical differences between reference and test data. This determination is made within a CABIN model developed specifically for various watersheds across Canada.

In this study, three general analysis steps were completed within the CABIN program:

- Model Selection,
- Model Building, and
- Test Site Assessment

Model Selection. The Yukon Model, developed by Bailey and Reynoldson (2010), was selected for this project. This model uses ten physical/geographic habitat characteristics to match a test site to one of five reference groups for the Yukon. There are a total of 226 reference sites categorized into five reference groups in the Yukon. The ten habitat characteristics include:

- Altitude
- Longitude
- Landcover – percent alpine, forest, unregenerated forest, and wetland
- Climate – rainfall in January, snowfall in June, temperature maximum in January.
- Stream density (m stream/km^2 catchment)

Bailey and Reynoldson (2010) found that these specific habitat characteristics were the best predictors of the type of benthic community present at a site.

Model Building. Each Pony Creek test site was matched to a group of reference sites in the Yukon River basin using Bray Curtis Similarities and Discriminate Function Analysis (Bailey and Reynoldson 2010). The Yukon CABIN model matches a test site with a group of reference sites based on the ten variables identified above. Additional habitat variables can be selected during the model building process to improve the classification of test sites (i.e. ensure that they are classified in the most appropriate reference group). For the Pony Creek assessment, latitude, dominant substrate size class, and average channel depth were included as additional habitat variables.

Altitude, dominant substrate size class, average channel depth, latitude and longitude for each site were determined in the field. Landcover, stream density and climate data were obtained through spatial data sources analyzed in ArcGIS. Data sources are consistent to those used for the reference sites classification (Bailey and Reynoldson 2010; S.Strachan pers. comm. 2012) and are described in more detail in Appendix B.

The study area selected for the spatial analysis was the Pony Creek watershed, and landcover proportion and stream density data were calculated only for the areas upstream of each test site up to the watershed boundary (Figure 1).

Test Site Assessment. The group of reference sites which was matched to the test site in the model-building step was then compared to determine if the community compositions were statistically different using the BEAST (BEnthic Assessment for SedimenT) analysis in the CABIN system. This method uses the multivariate statistical technique called ordination. Using relative abundances of benthic invertebrate groups at the family level, test sites are plotted in the same ordination space as matched reference sites.

Ordination is in three dimensional space and results are interpreted based on where the test site falls within three ellipses around the reference condition. The distance of the test site from the reference space indicates the level of impairment. Figure 2 illustrates one dimension of ordination space in a test site assessment. The three ellipses in ordination space are equivalent to the probability the test site is divergent from the reference condition. If the test site falls within the first ellipse, this means the community is not significantly different than what is expected at the 90% confidence interval. In other words, 90% of reference sites would fall within this range. Table 1 shows how results are interpreted for a test site falling within each ellipse, also called a band or a confidence ellipse. Three comparisons are made, Axis 1 versus 2, Axis 1 versus 3, and Axis 2 versus 3. If the test site is stressed in any comparison, impairment is indicated.

Basic abundance and diversity metrics were also calculated for each site using the analysis tools available in CABIN, including total abundance and total number of taxa. Bray Curtis analysis was also calculated, and measures the overall difference in community structure between reference and test sites, reaching a maximum value of one for two sites that are entirely different and a minimum of zero for sites that are identical (Rosenberg and Resh 1993).

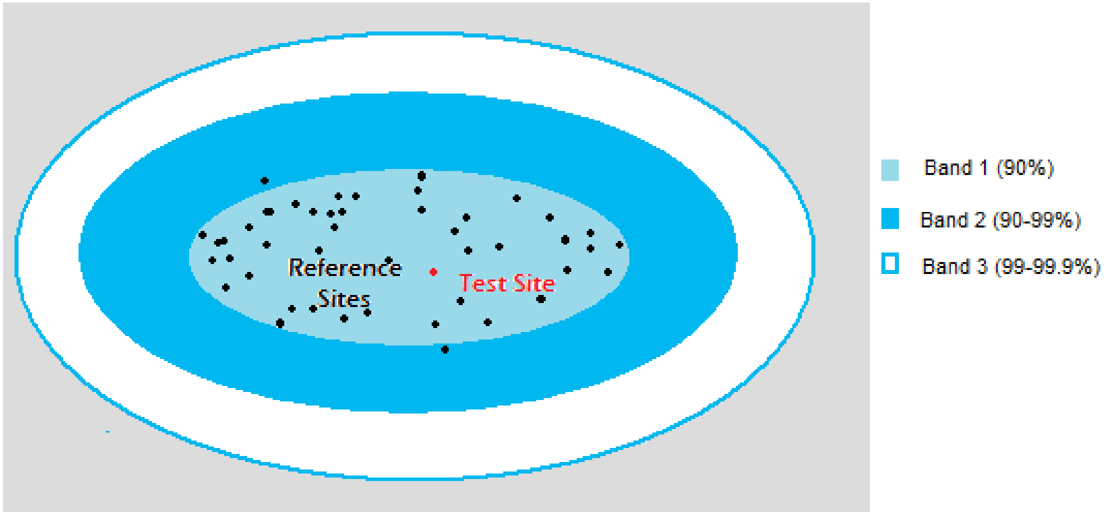

Figure 2. One dimension of ordination space between a test site (red) and its reference site group. Each ellipse is equivalent to a probability or confidence interval around the reference condition.

Table 1. Interpretation of probability ellipses around the reference condition.

Probability ellipse	Band	Result	Description
90 %	Band 1	Not stressed	Test site is similar or equivalent to reference condition.
90-99 %	Band 2	Potentially stressed	Test site is mildly divergent from reference, 10% of references sites could fall in this band.
99-99.9 %	Band 3	Stressed	Test site is divergent from reference condition. Less than 1% of reference sites could fall in this band.
Outside 99.9 %	Band 4	Severely stressed	Test site is highly divergent from reference condition. There is 0.1% chance of a reference site occurring.

3 RESULTS

Prior to data input into the CABIN database, the taxonomic classifications determined in 2008 were checked in 2011. Some corrections were made to the classifications from 2008, with no Trichoptera (caddisflies) identified at the P1A site and the identification of Coleoptera (beetles) and Hymenoptera (sawflies, wasps, bees and ants). Taxa within the Diptera order (true flies) dominated both the samples at both sites, followed by Plecoptera (stoneflies) as the second most dominant taxa (Table 2; Figure 3). The P1A site continued to have a higher density and diversity of invertebrates. The total number of individual invertebrates in each sample was noticeably low, particularly for the upstream site. A taxa count of 300 is typically desired for benthic invertebrate analysis, and the low taxa counts for both Pony Creek sites may affect the CABIN model's ability to effectively assess the benthic communities.

The following sections focus on results from the CABIN model-building and test site assessments completed in 2011/2012.

Table 2. Taxonomic classification for the Pony Creek test sites determined in 2011 (count numbers have been standardized to three-minute kick-net sample using multiplier).

Order	Family	P1A (downstream)	P2A (upstream)
Diptera	Chironomidae	86	33
Diptera	Tipulidae	3	3
Diptera	Ceratopogonidae	3	0
Diptera	Empididae	2	0
Diptera	Simuliidae	0	2
Plecoptera	Nemouridae	80	11
Coleoptera	Elmidae	12	0
Coleoptera		0	3
Hymenoptera		5	18
Unknown Adult		62	0
TOTAL		**251**	**69**

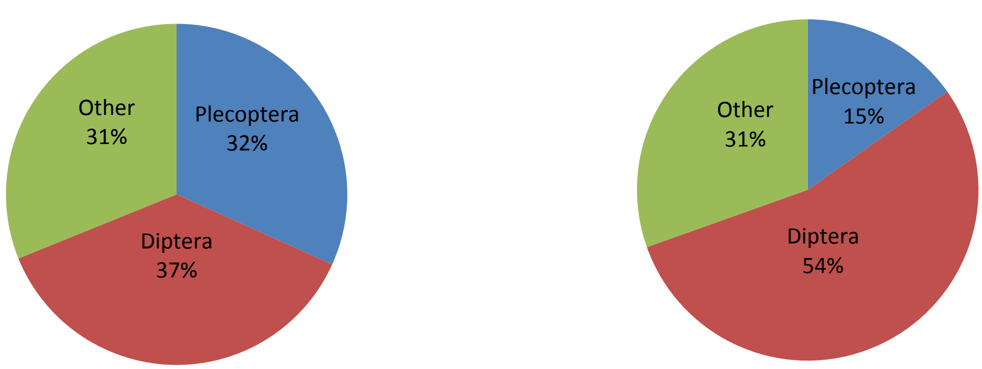

Figure 3. Relative proportions of the main benthic invertebrate orders found at the Pony Creek test sites, P1A (left) and P2A (right).

3.1 MODEL BUILDING

The selected model predictor variables assigned both Pony Creek sites to Reference Group 1 within the Yukon Model. The probability of the P1A site fitting within Reference Group 1 was 36.8%, followed by 20.6% for Group 3 and 20.2% for Group 4. The P2A site also had the highest probability of fitting within Reference Group 1 at 34.9%, followed closely by 32.4% for Group 3 and 19.1% for Group 4 (Table 3). These probabilities are based on the model being able to correctly predict the test sites to each reference group based on the habitat variables (model inputs). There are also error rates associated with each reference group, indicating the percentage chance that reference sites will be misclassified into the wrong reference group (Table 3). This is based on the inherent error within the model, as the model has some difficulty in discriminating Group 1 from Group 2 and 3. (Bailey and Reynoldson 2010).

There were some large differences in some habitat variables between the Pony Creek test sites and the reference group means, particularly regarding elevation, percent alpine, forest and unregenerated forest, stream density and channel depth (Table 4). In general, the Pony Creek site occurs at a higher elevation, with less alpine cover, more forest and unregenerated forest cover, higher stream density, and shallower stream depth than sites within Reference Group 1. All reference site data is provided in Appendix C.

Table 3. Model predictor probabilities for each Pony Creek site (highest probabilities are bolded) and error rates associated with each Reference Group.

	Group 1	Group 2	Group 3	Group 4	Group 5
Probabilities P1A (%)	**36.8**	10.7	20.6	20.2	11.6
Probabilities P2A (%)	**34.9**	5.4	32.4	19.1	8.3
Error Rate (%)	64.0	41.1	54.5	56.6	30.8

Table 4. Selected habitat attributes of each test site compared to mean habitat attributes of assigned reference group.

Habitat Variable	P1A	P2A	Group 1 Mean
Altitude (feet)	4,020	4,170	1,970
Longitude	-137.122	-137.132	-137.946
Landcover (% Alpine)	6.0	6.6	16.1
Landcover (% Forest)	79.3	80.9	39.0
Landcover (% Unregenerated Forest)	15.4	13.4	5.9
Landcover (% Wetland)	0	0	1.9
Climate (Rainfall JAN)	0	0	0.2
Climate (Snowfall JUN)	0.10	0.10	0.29
Climate (Max Temp JAN)	-22.7	-22.7	-20.3
Stream Density (m stream per km^2 catchment)	1,237	1,147	307
Average Channel Depth*	6	19.5	40.9
Dominant Substrate*	5	3	6
Latitude*	62.052	62.054	62.950

* additional predictor variables added to model

3.2 TEST SITE ASSESSMENTS & METRICS

Total abundance of taxa was highest at the downstream site, with 251 total individuals at P1A versus 69 individuals at P2A (Table 5). Taxa richness was also highest at the downstream site, with six different families identified at P1A and four families identified at P2A (Table 5). Both were below the reference site means for abundance (1,594) and richness (11.4; Table 5). The Bray Curtis Dissimilarity value for each site was 0.34 for P1A and 0.53 for P2A as compared to Reference Group 1. The values closer to zero represent test site communities that are most similar to reference communities, while values closer to one represent test site communities that are very different from reference communities. The results suggest that the benthic community at P1A is more similar to reference condition than the benthic community at P2A.

The results of benthic invertebrate test site assessments showed that P1A was 'potentially stressed' in two out of three of the probability ellipses for an overall assessment of potentially stressed (Table 6; Figure 4). The P2A was found to be 'stressed' in one ellipse, 'potentially stressed' in another ellipse, and 'unstressed' in the third ellipse for an overall assessment value of 'stressed' (Table 6; Figure 5). These results indicate the downstream Pony Creek site (P1A) was mildly divergent from reference condition and that only 10% of reference sites from Group 1 would fall within this band. While the upstream Pony Creek site (P2A) was found to be divergent from reference condition and that only 1% of the reference sites from Group 1 would fall within this band.

Table 5. Abundance, richness and similarity metrics for the Pony Creek sites compared to the reference site mean.

	P1A (downstream)	P2A (upstream)	Reference Mean
Total Abundance	251	69	1,594
Total No. of Taxa	6.0	4.0	11.4

Table 6. Test site assessment results for comparisons of Pony Creek test sites and the reference group condition.

	P1A (downstream)	P2A (upstream)
Vector 1 vs. Vector 2	Unstressed	Stressed
Vector 2 vs. Vector 3	Potentially stressed	Potentially Stressed
Vector 1 vs. Vector 3	Potentially stressed	Unstressed
Overall Assessment	Potentially stressed	Stressed

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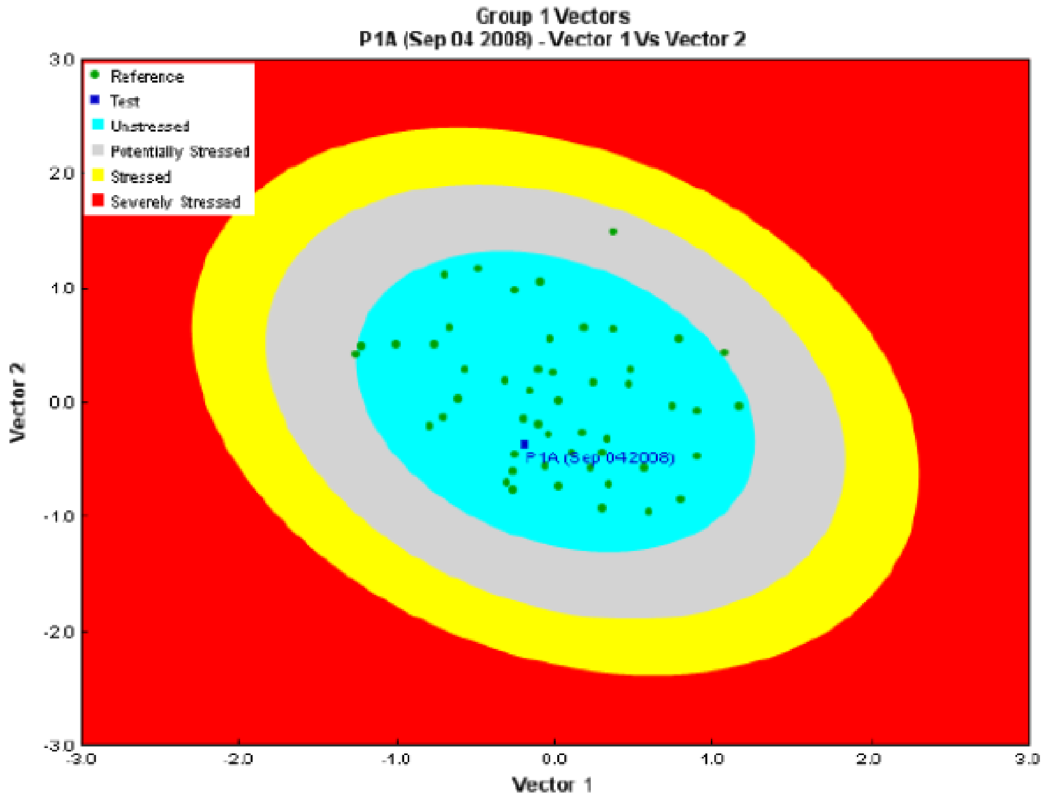
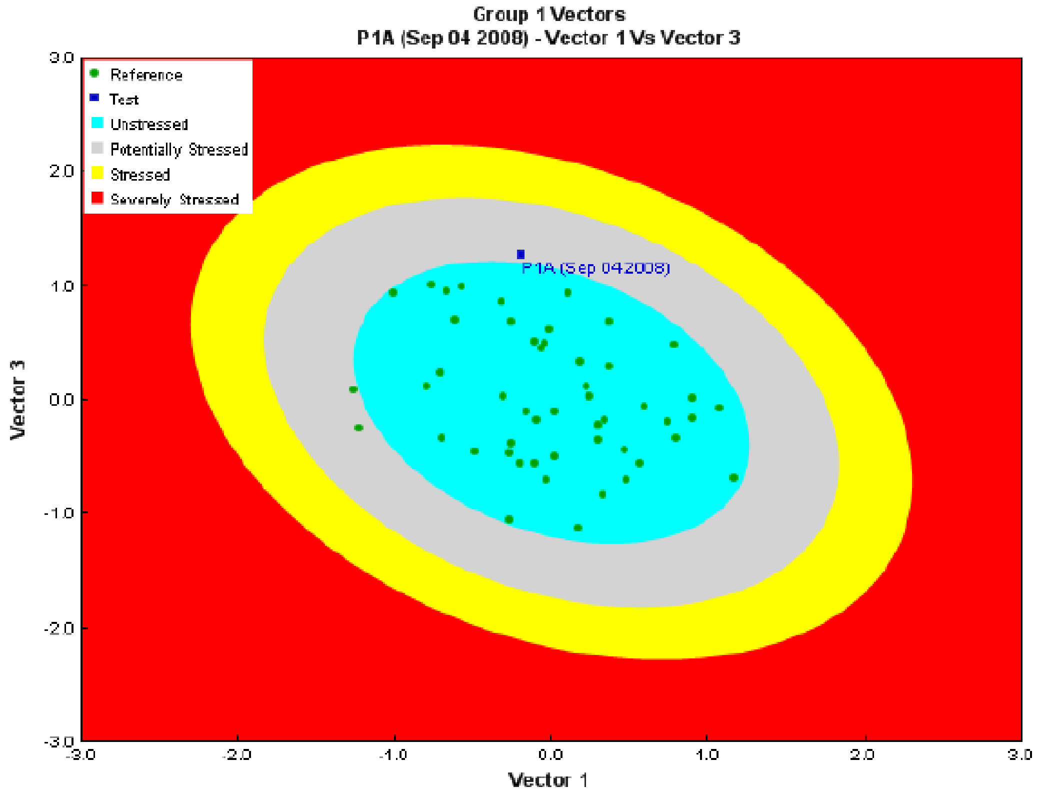
Figure 4. Site Assessment Graphs for Pony Creek Site P1A.





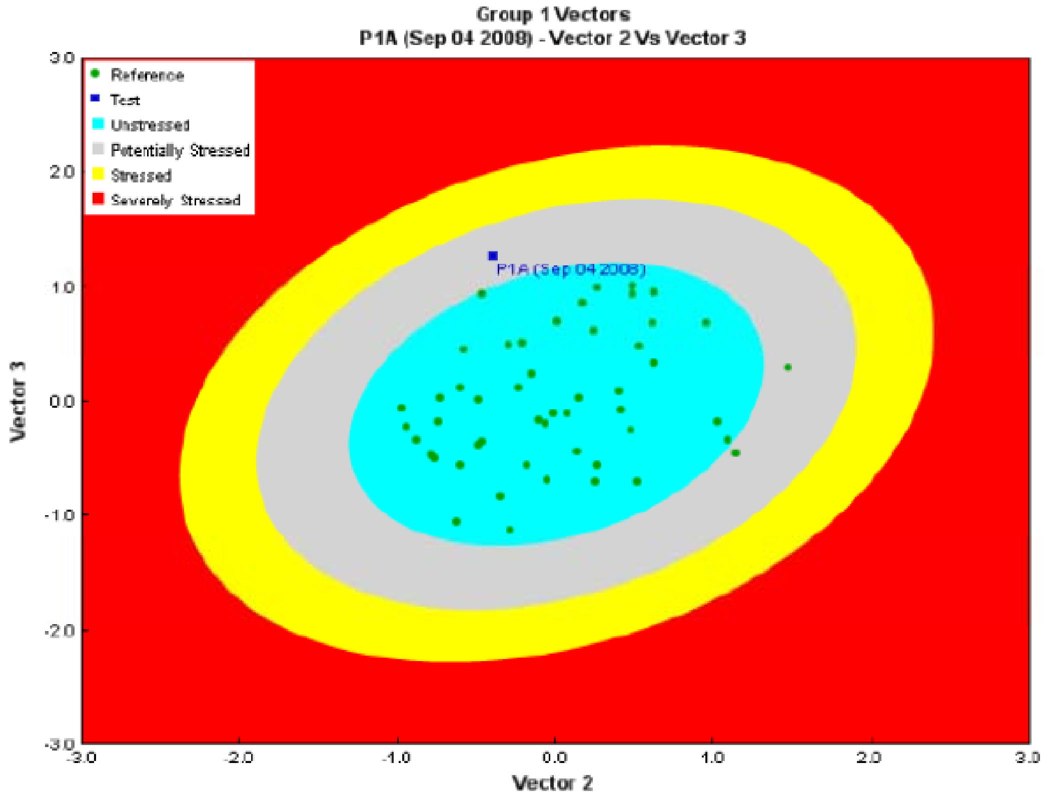
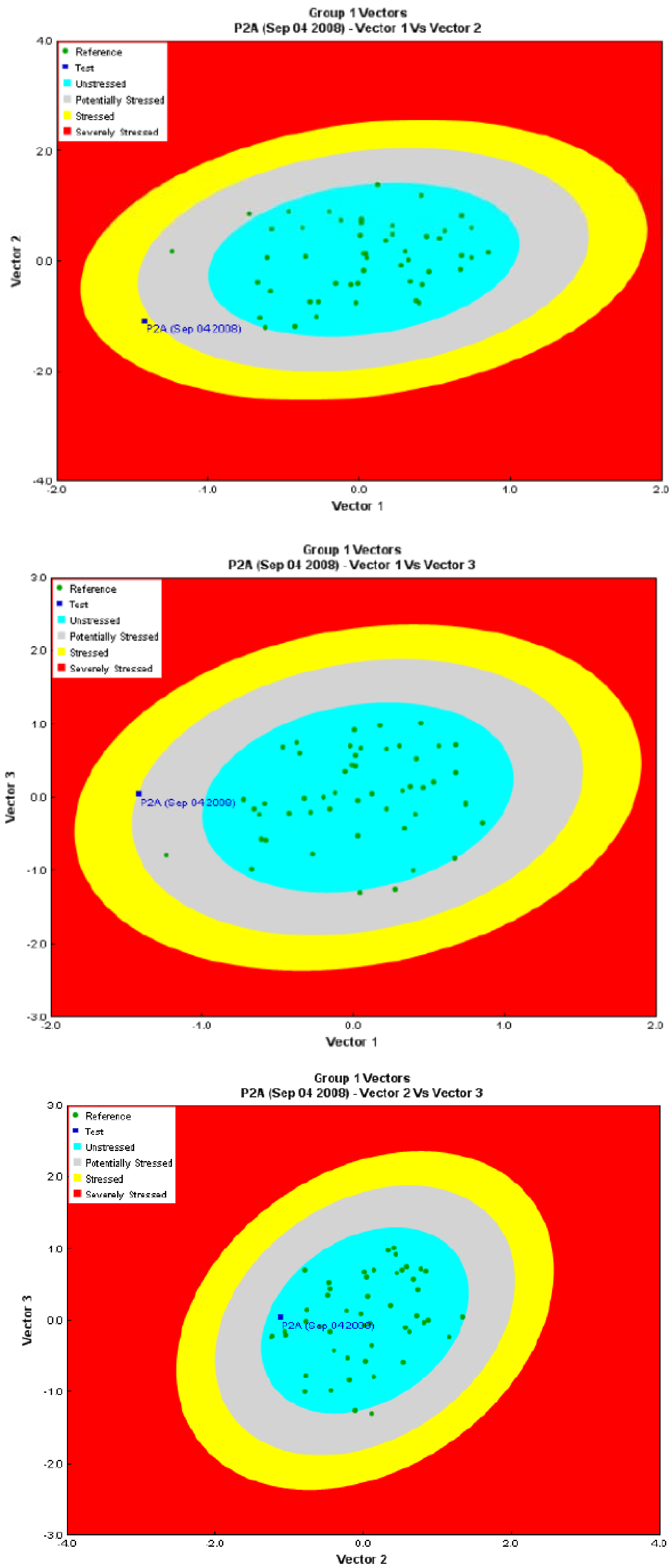


Figure 5. Site Assessment Graphs for Pony Creek Site P2A.



4 DISCUSSION & CONCLUSION

The CABIN model is designed as a screening tool to assess whether a site is in reference condition, but it cannot diagnose why a site is stressed or potentially stressed. We can design more detailed studies and determine possible causes by looking at additional information available, such as composition and ecology of the biota, their tolerance or sensitivity to pollution, as well as the habitat condition and water quality.

The Pony Creek test sites had relatively low abundance and richness of benthic invertebrates compared to the reference sites. Note, the total number of individual invertebrates in each sample was noticeably low, as a taxa count of at least 300 is typically desirable for biomonitoring studies (Rosenberg and Resh 1993), and taxa counts were 251 and 69 for P1A and P2A, respectively. Low numbers of invertebrates in a sample have the potential to misrepresent community composition and potentially miss rare invertebrates (Rosenberg and Resh 1993). This may affect the CABIN model's ability to provide conclusive results, and a larger sample size is recommended for more reliable assessment results. Future studies must include three-minute kick-net samples (according to CABIN protocols) and should consider additional sample sites within the study area for a greater confidence in the results.

Despite potential limitations of the small sample sizes, the analysis and assessment of the 2008 data is still valuable in providing an indication of general benthic abundance and richness, community composition, water quality, and ecosystem condition. In general the low abundance of invertebrates at the Pony Creek sites may be attributed to the small size of Pony Creek compared to the reference sites, as small streams typically have lower benthic invertebrate abundance and diversity than larger streams (Slack *et al.* 1979). The reference sites within Group 1 had a mean bankfull width of 14.3 m compared to 1.0 m for both Pony Creek sites. Average depths were also lower for the Pony Creek sites compared to the reference sites, with average depths of 6 cm and 20 cm on Pony Creek versus the reference group means of 41 cm and 44 cm.

Another factor potentially affecting the abundance and richness of invertebrates in Pony Creek may be attributed to the higher than normal precipitation and subsequent surface runoff experienced at the Mount Nansen site in 2008 (EDI 2009), which may have led to increased benthic invertebrate drift at the two sampling locations. Abnormally moderate to high water levels can lead to increased invertebrate drift away from an area, leading to a decrease in abundance and diversity (Quinn and Hickey 1990).

Species composition at both test sites was dominated by Diptera (mostly from the Chironomidae family), followed by Plecoptera (all from the Nemouridae family). This is similar to results from other sites within the Mount Nansen site, including Dome Creek and Victoria Creek (EDI 2008b). Despite similar species composition at both sites, abundance and richness measures were greater for the downstream, waste rock impacted site. This result may be attributed to habitat differences mainly associated with substrate sizes. Substrate at the upstream site was dominated by gravel and silty fines, while the downstream site was dominated by large pebbles. In general, pebble and cobble substrates provide a more complex, three-dimensional habitat resulting in a wider range of microhabitats and refuge areas from predation and high flows (Quinn and Hickey 1990). Thus, the greater micro-habitat diversity at the downstream site may have contributed to greater taxonomic richness and invertebrate abundance.

In terms of test assessment results, the CABIN model found that both sites had the highest probability of belonging to Reference Group 1 and that P1A was found to be mildly divergent from reference condition while P2A was found to be divergent. However, within the model, the Pony Creek test sites also had high probabilities of belonging to other reference groups, particularly Group 3 and Group 4. Test assessment results are highly dependent on which reference group is selected through the CABIN model, which in turn depends on the habitat predictor variables selected. For example if Reference Group 4 was selected for comparison, the upstream P2A site would be considered 'severely stressed', whereas if Reference Group 3 was selected the same site would be considered 'unstressed'. Thus, when test sites have similar probabilities of belonging to more than one reference group, some discretion is required when interpreting the CABIN assessment results, especially when there are also concerns that sample sizes may be too small.

To aid with interpretation of the Pony Creek test assessments, it is useful to look at the general characteristics of each reference group described by Bailey and Reynoldson (2010). Sites within Group 1 were characterized by intermediate relative benthic abundance levels, moderate substrate sizes, and a low amount of alpine landcover in the catchments. Group 3 sites were characterized by a depauperate benthic community with the lowest overall family richness of any reference group, with small stream substrate sizes and low snowfall and high rainfall typical of areas in the western portion of the Yukon. Group 4 sites were identified as having a more abundant and rich benthic community, with high rainfall and stream density, more typical of the northwestern part of the Yukon. In terms of substrate size, the P1A site appears to be most similar in terms of habitat to Group 1, while P2A appears to be most similar to Group 1 or 3. There were also other habitat and climate similarities as group membership probabilities for both Pony Creek sites were quite high for each of these groups.

While it is possible within the CABIN model to select the reference group with which to compare within the assessment, it is highly recommended to compare the test sites with the reference group selected by CABIN (the group with the highest probability), unless there is good justification to select the next closest group for the assessment (S. Strachan, pers. comm. 2012). One should not select the reference group based on the most advantageous or favourable assessment result.

Regardless of which reference group is selected through the CABIN model, the biomonitoring assessment results for the Pony Creek test sites identified some level of stress within the watershed. The impacts of recent mining activity on the upstream P2A site were expected to be minimal as the site lies upstream of the road crossing and waste rock pile location. Water quality at this site supports this statement, as the site is characterized by low suspended sediment, high dissolved oxygen levels, pH and conductivity values within normal ranges, and relatively low metal concentrations (EDI 2008c; EDI 2009). Despite the relatively good water quality and limited mining impacts at the site, the CABIN assessment identified the P2A site as 'stressed'. This may be attributed to the lower relative abundance and richness at the site compared to the reference group, which may be related to the small sample size issue discussed earlier.

The test assessment results for P1A, the downstream site, found the site to be 'potentially stressed' and mildly divergent from reference condition. Water quality was similar to the upstream site in terms of low suspended sediments, high dissolved oxygen levels, and pH and conductivity levels within normal ranges;

however, metal concentrations exceeded guidelines for arsenic, cadmium, copper and zinc through the 2008 open water season (EDI 2008c; EDI 2009). This effect has been attributed to the impacts of the waste rock pile that was located just upstream of the P1A site and may be the cause for the 'potentially stressed' assessment result. Also, during the waste rock removal in July 2008, total metal levels increased sharply downstream, near the location of the P1A benthic sampling site (EDI 2009).

Despite the higher contaminant loads at the downstream site, abundance of Plecoptera at this site was relatively high, composing 32% of the sample, and species from this taxonomic order are considered sensitive to disturbance, including exposure to contaminants associated with hard rock mining (Maret *et al.* 2003). Plecoptera were also found at the upstream site, composing 15% of the sample. Relative abundance of Plecoptera has also increased from previous monitoring results for the creek from 1997, when a benthic sample was collected from just upstream of the P1A site (Environment Canada 2012). The 1997 results found less than one percent of the sample was composed of Plecoptera (Environment Canada 2012), suggesting potential improving conditions at the downstream site over time.

Also during the 1997 sampling event, the sample was dominated by Nematoda (roundworms) and Annelida (ringed worms) which made up 55% of the sample (Environment Canada 2012). These taxa are considered pollution tolerant and when found in high numbers are considered indicators of very poor water quality (Reynoldson *et al.* 2003). Thus the absence of these organisms from either sample collected in 2008 is another sign that water quality has improved.

In conclusion, the results of this biomonitoring assessment will provide a useful comparison in determining overall success of remediation actions at the Mount Nansen site. At the local stream level there is also an opportunity to assess potential recovery of the Pony Creek site following removal of the waste rock pile and subsequent revegetation of the area using bioengineering techniques (EDI 2008a). Aquatic ecosystem conditions in Pony Creek have already appeared to improve from 1997 to 2008, and with additional time for remediation following waste rock removal, aquatic health and water quality may have improved further. There may be a unique opportunity to conduct an additional assessment in 2012 to assess conditions four years after completion of initial remediation work. Such a study should focus on sampling a few additional locations on Pony Creek, both upstream and downstream of the waste rock location to better assess current conditions.

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Strachan, Stephanie. Environmental Monitoring Scientist (Biological Assessment). Pacific and Yukon Water Quality Monitoring, Water Quality Monitoring and Surveillance Division, Science and Technology Branch, Environment Canada. via email with EDI on Feb 7, 2012 and November 14, 2011.

APPENDIX A CABIN DATABASE INPUTS

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Table A-1: Basic site information inputs to CABIN database for Pony Creek sites P1A and P2A.

Variable	P1A	P2A
Stream Name	Pony Creek	Pony Creek
Basin	Victoria Creek	Victoria Creek
Stream Order (1:50000)	1	1
Eco-Region	Klondike Plateau	Klondike Plateau
Eco-Zone	Boreal Cordillera	Boreal Cordillera
Sampling Device	Kick Net	Kick Net
Protocol	CABIN - Wadeable Streams	CABIN - Wadeable Streams
Date	Sep 4, 2008	Sep 4, 2008
Sample(s) Taken	1	1
Kick Time (Min)	2	2
Mesh Size (µ.m)	363	363
Description	Downstream of waste rock	Upstream of culvert
Latitude & Longitude	62.0525, -137.122222222	62.053888889, -137.1325
Altitude (feet)	4020	4170
Crew	L. Doetzel & M. Marjanovic	L. Doetzel & M. Marjanovic

Table A-2: Basic water chemistry inputs to CABIN database for Pony Creek sites P1A and P2A.

Variable	P1A	P2A
Bottom Dissolved Oxygen (mg/L)	11.1	11.1
Conductivity (µs/cm)	345	302
pH	7.06	7.1
Temperature (°C)	2.5	2.3

Table A-3: Taxonomic classification inputs to CABIN database for Pony Creek site P1A.

Phylum	Class	Order	Family	Count
Arthropoda	Insecta	(unknown adult)		62
Arthropoda	Insecta	Coleoptera	Elmidae	12
Arthropoda	Insecta	Diptera	Ceratopogonidae	3
Arthropoda	Insecta	Diptera	Chironomidae	86
Arthropoda	Insecta	Diptera	Empididae	2
Arthropoda	Insecta	Diptera	Tipulidae	3
Arthropoda	Insecta	Hymenoptera		5
Arthropoda	Insecta	Plecoptera	Nemouridae	80

Table A-4: Taxonomic classification inputs to CABIN database for Pony Creek site P2A.

Phylum	Class	Order	Family	Count
Arthropoda	Insecta	Coleoptera		3
Arthropoda	Insecta	Diptera	Chironomidae	33
Arthropoda	Insecta	Diptera	Simuliidae	2
Arthropoda	Insecta	Diptera	Tipulidae	3
Arthropoda	Insecta	Plecoptera	Nemouridae	11
Arthropoda	Insecta	Hymenoptera		18

Table A-5: Basic habitat information inputs to CABIN database for Pony Creek sites P1A and P2A.

Variable	P1A	P2A
% Canopy Coverage	0	0
Avg. Channel Depth	6	19.5
Avg. Velocity	0.31	0.09
Bank Full Width	0.95	1
Direct Velocity Measurement Instrument	3	3
Dominant Streamside Vegetation	2	2
Max. Channel Depth	8	1
Max. Velocity	0.67	30
Pool in Reach	1	0.23
Presence of Coniferous Trees	1	1
Presence of Deciduous Trees	0	0
Presence of Grasses	0	0
Presence of Shrubs	1	1
Rapid in Reach	0	1
Riffle in Reach	1	0
Straight Run in Reach	0	1
Velocity Measurement Method	3	3
Precip. Rainfall JAN (mm)	0	0
Precip. Snowfall JUN (mm)	0.10	0.10
Temp. Max. JAN (°C)	-22.7	-22.7
Stream density (m/km^2)	1,237.32	1,147.27
Landcover Alpine (%)	6.04	6.55
Landcover Forest (%)	79.31	80.92
Landcover Unregen. Forest (%)	15.45	13.4
Landcover Wetland (%)	0	0
2nd Dom. Substrate	4	2
Dominant Substrate	5	3

APPENDIX B MODEL INPUT METHODOLOGY

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Methodology for selecting inputs for CABIN model

Pony Creek Stream Layer: Delineated Pony Creek stream layer using Quickbird satellite imagery (25 cm resolution). Filename: alpha_oMtNansen_QB_02Sept2008_utm8.tif. Imagery was available for the area, however; 1:50,000 Canvec watercourse layer could also be used in lieu of imagery.

Pony Creek Drainage Area: Delineated Pony Creek watershed layer using newly digitized stream layer (as above), 1:50:000 Canvec contour layer (20 m intervals), and digital elevation model (30 m resolution).

Anthropogenic/Disturbance Layer: A road layer was collected by EDI using GPS from past visits in the area. Roads were initially in linear format; a general 7.5 m buffer was applied to the layer to give the roads an areal perspective.

Disturbance (mining and related) areas were digitized using Quickbird satellite imagery (25 cm resolution). Filename: alpha_oMtNansen_QB_02Sept2008_utm8.tif. Roads (areal) were merged into this file to produce a full disturbance layer.

Forest and Alpine Cover: A forest cover was derived using 1:40,000 forest cover data provided by Yukon Government - Forest Management Branch; date of modified layer was 2003. This layer also includes land position information and the alpine percentage value was derived from this layer.

The forest cover layer and disturbance layer were merged into one file and the disturbance was taken out leaving only vegetated areas. This step ensures that there is no overlap in vegetated and non-vegetated areas.

Forest layer includes shrub and treed.

Wetland Area: Wetlands were assessed for the area using 1;50,000 Canvec data (TRIM/ 1:20,000 is not available for Yukon). This step revealed no wetlands in the extent of Pony Creek Drainage area.

Final Process: All shapefiles and inputs were clipped to the Pony Creek watershed layer; first set was clipped above the first point occurring on the stream (08N 388847 6881823) and second set included layers above the second point on the stream (08N 389166 6881723).

Once clipped, areal/linear geometry was then calculated for each file.

Climate Data Inputs

The *Canadian Ecodistrict Climate Normal's (1961-1990)* data was used to gather precipitation and temperature data for the climate model input variables. This is the data source that was used for the Yukon reference sites climate data. Data is Accessible from
http://sis.agr.gc.ca/cansis/nsdb/ecostrat/district/climate.html

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APPENDIX C REFERENCE SITES

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Table C-1: Summary of reference and test site model predictor variables.

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-002	2303	2.64	15.29	60.5	3.48	6	0.2	0.1	296.37	60.233	-133.899	32.16	-15	3
YPS-003	2598	12.23	29.3	0	6.42	5	0.2	0.1	353.81	60.502	-133.267	47.67	-15	1
YPS-004	2946	21.55	9.61	0	1.9	7	0.2	0.1	309.02	60.521	-133.211	37.83	-15	2
YPS-005	3700	18.5	8.55	0	9.76	7	0.2	0.1	193.81	60.614	-133.046	23.73	-15	1
YPS-006	2201	4.13	25.6	27.38	2.74	5	0	0	362.98	61.632	-135.887	40.81	-21.9	1
YPS-007	1601	0	19.85	51.79	0.51	5	0	0	323.57	62.536	-136.766	23	-21.9	1
YPS-008	2099	0	77.63	20.64	0.38	5	0	0	355.8	63.002	-136.49	26.88	-21.9	2
YPS-012	1558	0.6	88.24	1.54	0.22	4	0	0	308.96	63.508	-137.021	37.33	-21.4	1
YPS-013	2001	3.8	83.03	1.91	2.71	6	0	0	336.11	63.787	-137.821	16.08	-21.4	1
YPS-014	3399	37.35	0	0	0	7	0	0	333.5	64.505	-138.224	30.48	-21.8	2
YPS-015	2526	48.59	6.54	0	0	8	0	0	411.67	64.279	-138.491	23.22	-21.8	2
YPS-017	2299	65.37	6	10.12	0	7	0.6	0.5	259.21	60.799	-135.999	18.83	-15.1	2
YPS-018	2473	8.9	24.92	3.69	7.58	3	0.2	0.1	344.67	60.389	-134.128	33	-15	1
YPS-019	2473	2.64	15.29	60.5	3.48	2	0.2	0.1	344.67	60.389	-134.128	33	-15	3
YPS-020	2263	0	44.55	0	7.57	3	0.1	0.1	483.69	60.129	-132.72	26.79	-15	1
YPS-021	2257	0	57.85	0	9.63	7	0.1	0.1	297.99	60.117	-132.703	20.71	-15	3
YPS-022	2267	1.91	49.67	0	7.25	5	0.2	0.1	287	60.183	-132.791	31.67	-15	2
YPS-023	2273	18.39	9.77	16.52	5.18	7	0.2	0.1	326.89	60.339	-133.064	54.86	-15	2
YPS-025	3546	37.28	0	0	0	7	0.2	0.1	316.76	60.546	-133.171	20.81	-15	2
YPS-026	2588	59.67	3.72	0	0.52	7	1.2	0.4	365.55	61.489	-139.275	13.33	-15.7	2
YPS-027	2569	53.48	13.25	0	0	7	1.2	0.4	229.12	61.369	-138.699	35.25	-15.7	1
YPS-028	2578	2.47	19.25	0	0	4	1.2	0.4	242.05	61.387	-138.744	35.71	-15.7	3
YPS-031	1801	0	44.71	31.84	0.53	4	0	0	361.04	62.078	-136.065	20.6	-21.9	1
YPS-033	1099	0	98.58	0	0	6	0	0	386.22	64.250	-139.726	14.9	-22.5	1
YPS-034	1099	0	98.89	0	0	6	0	0	307.13	64.224	-139.596	35.4	-22.5	2
YPS-035	1099	0	100	0	0	6	0	0	298.49	64.172	-139.544	22.3	-22.5	2
YPS-036	1049	0	100	0	0	6	0	0	336.31	64.105	-139.467	17	-22.5	1
YPS-037	1102	0	22.11	32.48	0	6	0	0	289.94	63.762	-139.755	25.1	-22.5	1
YPS-038	1099	0	14.34	80.3	0	6	0	0	342.45	63.792	-139.775	32.1	-22.5	2
YPS-039	1099	0	46	53.85	0	5	0	0	294.47	63.919	-139.74	29.5	-22.5	2
YPS-040	1099	0	99.58	0.4	0	7	0	0	364.64	63.964	-139.662	11.9	-22.5	1

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-041	823	0	100	0	0	3	0	1.3	343.25	67.582	-139.613	17.5	-27.2	3
YPS-042	826	0	81.67	0	13.15	3	0	1.3	33	67.558	-139.463	26.4	-27.2	2
YPS-043	823	0	84.52	0	9.46	7	0	1.3	25	67.524	-139.331	16	-27.2	1
YPS-044	849	0	96.97	0	0	7	0	1.3	259.3	67.547	-139.164	12.2	-27.2	3
YPS-045	803	0	66.12	0	12.61	3	0	1.3	227.27	67.530	-139.876	14.8	-27.2	2
YPS-046	823	0	13.28	0	8.41	4	0	1.3	302.93	67.530	-139.935	47.8	-27.2	1
YPS-047	800	0	80.35	0	1.92	3	0	1.3	193.03	67.506	-139.893	15.6	-27.2	1
YPS-048	800	0	24.54	0	26.83	2	0	1.3	50	67.514	-139.992	21.5	-27.2	1
YPS-049	800	0	45.73	0	23.93	3	0	1.3	30	67.480	-140.173	13.9	-27.2	3
YPS-050	800	0	27.18	0	59.75	3	0	1.3	292.68	67.487	-140.258	51	-27.2	3
YPS-056	2067	20.39	14.22	0	1.36	7	0.2	0.8	357.27	61.116	-135.091	50.5	-14.6	1
YPS-057	2178	28.84	24.18	0	2.5	3	0.3	0.4	424.48	60.115	-134.926	18.2	-13.6	1
YPS-058	2201	30.98	19.95	0	2.68	6	0.3	0.4	455.97	60.110	-134.924	22.4	-13.6	2
YPS-059	2198	30.41	18.51	0	0	6	0.3	0.4	297.23	60.051	-135.022	50.2	-13.6	2
YPS-060	2217	79.35	1.89	0	0	4	0.3	0.4	376.68	60.052	-135.029	12.9	-13.6	2
YPS-061	2247	25.78	11.51	0	0.17	3	0.5	0.6	243.2	60.488	-136.145	13	-14.8	1
YPS-062	2211	44.54	6.66	0	0	7	1.1	0	306.33	60.414	-136.279	60.6	-15.7	2
YPS-063	2208	88.13	11.09	0	0.05	3	1.2	0.4	256.3	60.352	-136.4	15.8	-15.7	1
YPS-064	2204	66.98	1.57	0	0	6	1.1	0	333.56	60.347	-136.315	33.3	-15.7	2
YPS-065	2578	61.76	0	0	0	6	1.2	0.4	243.88	61.402	-138.651	10.5	-15.7	2
YPS-066	2569	79.25	0.03	0	0	6	1.2	0.4	353.59	61.450	-138.608	31.2	-15.7	2
YPS-067	2572	88.92	0.32	0	0	6	1.2	0.4	329.2	61.597	-138.662	54	-15.7	2
YPS-068	2565	93.35	0.05	0	0	3	1.2	0.4	365.25	61.577	-138.685	21.3	-15.7	2
YPS-069	2569	96.3	0	0	0	6	1.2	0.4	330.26	61.520	-138.656	23.6	-15.7	2
YPS-071	2201	20.34	31.91	0	0.45	6	0.2	0.1	386.02	60.190	-134.275	28.1	-15	2
YPS-072	2201	30.84	19.46	0	0.95	3	0.2	0.1	278.19	60.135	-134.258	42.4	-15	2
YPS-073	2201	43.54	12	0	0	3	0.2	0.1	381.5	60.130	-134.312	35	-15	1
YPS-074	2201	14.88	44.49	0	5.29	3	0.2	0.1	348.97	60.406	-134.299	19.2	-15	2
YPS-075	2201	17.92	56.47	0	3.82	5	0.2	0.1	380.66	60.439	-134.323	47.2	-15	1
YPS-076	2201	16.24	23.74	0	0	6	0.2	0.1	370.68	60.618	-134.806	19.3	-15	1
YPS-120	1375	16.97	0.79	20.97	0	7	0	0	276.2	63.672	-139.609	85	-22.5	1
YPS-121	1425	0	2.82	24.1	0	3	0	0	331.95	62.893	-138.77	75	-22.5	1

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-122	1475	0	2.82	24.1	0	3	0	0	309.15	62.866	-138.572	50	-22.5	2
YPS-123	2350	16.97	0.79	20.97	0	7	0	0.1	317.02	62.650	-138.306	30	-22.7	2
YPS-126	1675	2.78	44.01	0.26	0.14	7	0	0.1	318.79	63.249	-140.383	175	-22.7	3
YPS-127	1475	2.78	44.01	0.26	0.14	7	0	0.1	312.54	63.266	-140.8	175	-22.7	1
YPS-128	1375	2.78	44.01	0.26	0.14	3	0	0.1	317.45	63.153	-140.408	150	-22.7	3
YPS-129	1475	2.78	44.01	0.26	0.14	6	0	0.1	306.68	62.956	-140.234	150	-22.7	1
YPS-130	1450	2.78	44.01	0.26	0.14	2	0	0.1	333.46	62.909	-140.278	150	-22.7	1
YPS-131	1975	2.78	44.01	0.26	0.14	2	0.1	0.3	701.19	62.932	-140.959	150	-22.9	4
YPS-132	2050	2.78	44.01	0.26	0.14	3	0.1	0.3	344.81	62.982	-140.989	100	-22.9	1
YPS-133	1875	2.78	44.01	0.26	0.14	2	0.1	0.3	259.45	62.838	-140.893	200	-22.9	4
YPS-134	2300	14.66	85.34	0	0	7	0	0	280.95	63.986	-135.86	75	-21.9	2
YPS-135	2275	14.66	85.34	0	0	7	0	0	310.33	63.798	-134.702	100	-21.9	1
YPS-136	2650	14.66	85.34	0	0	7	0	0	284.83	64.021	-135.667	100	-21.9	4
YPS-137	2175	14.66	85.34	0	0	6	0	0	282.7	63.612	-134.732	100	-21.4	3
YPS-138	2675	14.66	85.34	0	0	7	0	0	278.74	63.655	-134.534	50	-21.4	3
YPS-139	2475	14.66	85.34	0	0	7	0	0	304.7	63.739	-134.574	100	-21.4	1
YPS-141	2300	14.66	85.34	0	0	7	0	0	347.42	63.965	-136.347	40	-21.9	2
YPS-142	1125	16.97	0.79	20.97	0	7	0	0	283.44	63.710	-139.675	50	-22.5	1
YPS-143	1175	16.97	0.79	20.97	0	3	0	0	290.38	63.282	-139.239	100	-22.5	3
YPS-144	2125	11.73	88.27	0	0	7	0	0	324.72	63.947	-136.499	54.6	-21.9	2
YPS-150	1137	0	73.5	20.31	0	2	0	0	292.84	63.897	-139.715	45	-22.5	4
YPS-154	1337	16.97	0.79	20.97	0	3	0	0.1	324.3	62.952	-139.483	40	-22.7	2
YPS-155	2369	40.21	59.79	0	0	7	0	0	289.12	63.753	-136.833	58	-21.9	2
YPS-156	2079	0	99.59	0	0.41	7	0	0	320.59	63.736	-135.86	60	-21.9	4
YPS-157	2201	0	99.59	0	0.41	6	0	0	326.61	63.769	-135.844	40	-21.9	4
YPS-162	2330	1.6	25.61	0.15	0.08	7	0	0	277.52	63.458	-139.965	31	-22.5	4
YPS-163	1961	17.53	43.47	0	0	7	0	0	315.37	63.801	-136.512	29	-21.9	4
YPS-167	2170	14.66	85.34	0	0	7	0	0	291.5	64.066	-136.264	28	-21.9	4
YPS-251	3044	41.85	2.69	0	0	1	1.5	0.6	374.19	61.801	-138.429	52.8	-15.3	4
YPS-197	3615	40.52	4.69	0	0	7	0	0.1	288.05	62.361	-137.9	37.21	-22.7	4
YPS-198	2893	3.72	0.7	0	0	7	0	0.1	344.6	62.427	-137.601	18	-21.9	4
YPS-199	2162	1.39	16.04	0	0	6	0	0.1	309.45	62.346	-137.136	37.21	-21.9	4

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-200	1886	9.88	10.03	1.31	0.06	1	0	0	339.05	62.463	-137.049	0.133	-21.9	4
YPS-202	2014	0.87	48.64	0	0	5	0	0	333.73	63.130	-136.258	0.383	-20.8	4
YPS-203	2096	18.72	25.95	0	0.37	8	0	0.1	299.36	62.341	-137.015	21.4	-21.9	4
YPS-204	3212	17.46	37.12	0	0.72	7	0	0.1	367.62	62.026	-137.056	11.67	-22.7	2
YPS-205	1200	16.97	0.79	20.97	0	5	0	0	286.88	63.234	-139.08	0.16	-22.5	3
YPS-206	1181	16.97	0.79	20.97	0	1	0	0	291.31	63.282	-139.239	16.66	-22.5	3
YPS-207	1243	16.97	0.79	20.97	0	1	0	0	358.09	63.205	-138.827	23.6	-22.5	3
YPS-208	1217	16.97	0.79	20.97	0	1	0	0	301.16	63.188	-139.008	0.626	-22.5	3
YPS-209	1210	16.97	0.79	20.97	0	1	0	0	309.35	63.211	-139.051	30	-22.5	3
YPS-210	1089	0	99.96	0	0	7	0	0	329.98	63.999	-139.625	12.33	-22.5	1
YPS-211	1112	0	99.66	0.34	0	6	0	0	339.24	63.964	-139.662	12	-22.5	1
YPS-212	1099	0	90.15	0	0	8	0	0	293.81	63.839	-139.725	13.3	-22.5	1
YPS-213	1105	0	83.91	5.6	0	7	0	0	243.8	63.934	-139.694	13	-22.5	2
YPS-168	1800	9.88	10.03	1.31	0.06	6	0	0.1	321.89	62.520	-137.055	43	-21.9	4
YPS-169	1967	9.88	10.03	1.31	0.06	3	0	0.1	326.64	62.427	-137.078	8.3	-21.9	4
YPS-170	2846	13.42	11.05	0	0	6	0	0.1	341.85	62.444	-137.631	24.33	-21.9	4
YPS-171	2661	25.24	1.35	0	0	6	0	0.1	300.4	62.390	-137.468	14	-21.9	5
YPS-173	6571	0.43	64.24	0.23	0.22	5	0	0	326.49	63.154	-136.324	24	-20.8	4
YPS-174	1402	0	48.87	34.27	0	8	0	0	371.65	63.507	-137.827	25	-22.5	4
YPS-175	1301	16.97	0.8	21	0	8	0	0	247.56	63.387	-138.2	14.3	-22.5	4
YPS-176	4262	16.92	0.81	20.98	0	8	0	0	295.13	63.299	-138.421	7.6	-22.5	4
YPS-177	1499	16.97	0.79	20.97	0	2	0	0	361.57	63.293	-138.585	25	-22.5	1
YPS-178	4199	16.97	0.79	20.97	0	1	0	0	246.95	63.297	-138.609	42.6	-22.5	1
YPS-179	1068	0	68.11	0	0	7	0	0	316.56	64.339	-140.849	9	-22.5	1
YPS-181	1066	0	31.41	0	0	8	0	0	328.96	64.308	-140.973	13.3	-22.5	2
YPS-182	1070	0	41.74	0	0	7	0	0	308.83	64.321	-140.946	12.67	-22.5	1
YPS-183	3320	4.55	31.18	33.56	0	7	0	0	305.38	64.319	-140.004	20.8	-22.5	1
YPS-185	1036	0	100	0	0	6	0	0	300.74	64.173	-139.545	6.6	-22.5	1
YPS-186	2687	36.54	0.14	0	1.13	6	0.2	0.1	379.64	61.198	-133.197	19.75	-15	2
YPS-187	2605	43.53	1.92	0	3.16	6	0.2	0.1	338.88	61.212	-133.238	34.4	-15	2
YPS-188	2578	14.65	7.53	0	0.12	2	0.2	0.1	277.22	61.281	-133.314	26.3	-15	2
YPS-189	2952	34.92	2.42	0	1.13	7	0.2	0.1	273.74	61.311	-133.323	17.3	-15	2

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-190	2854	47.64	0.27	0	2.89	8	0	0	324.98	61.313	-133.456	75	-16.3	2
YPS-191	2562	35.83	10.06	0	2.42	4	0.2	0.1	345.89	61.414	-133.477	20	-15	4
YPS-192	2546	27.9	2.97	0	0.98	5	0	0	305.26	61.409	-133.479	28	-16.3	2
YPS-193	2523	46.96	0.83	0	5.91	7	0	0	323.37	61.480	-133.511	33.4	-16.3	2
YPS-194	2998	37.62	0	0	4.45	4	0	0	310.85	61.574	-133.632	18.2	-16.3	2
YPS-195	2411	35.7	0.25	0	0.43	6	0	0	269.52	61.600	-133.705	49.8	-16.3	2
YPS-196	2447	34.86	0.48	0	1.68	7	0	0	307.15	61.620	-133.747	29.8	-16.3	2
YPS-252	3290	68.55	0	0	0	5	2	0.3	319.13	61.880	-138.501	17.6	-14.9	4
YPS-253	2575	18.84	11.64	0	0	3	2	0.3	162.33	62.003	-138.346	15.4	-14.9	4
YPS-254	3356	98.7	0	0	0	5	1.5	0.6	292.05	61.915	-138.721	22.6	-15.3	4
YPS-255	3176	70.09	0	0	0	4	1.5	0.6	260.73	61.906	-138.814	33.4	-15.3	4
YPS-256	3130	47.88	0.85	0	0	2	0.9	0.8	283.66	61.860	-138.837	67.8	-15.6	1
YPS-257	2979	61	0	0	0	5	0.9	0.8	356.89	61.891	-138.945	20.5	-15.6	2
YPS-258	2706	21.67	8.71	0	0	0	1.1	0.6	405.42	61.839	-139.276	49.8	-15.7	4
YPS-259	3970	99.71	0	0	0	4	1.2	0.7	305.89	61.069	-139.366	17.4	-16	1
YPS-260	3805	99.86	0	0	0	7	1.2	0.7	362.99	61.142	-139.446	43.5	-16	3
YPS-261	4006	100	0	0	0	2	1.2	0.7	262.45	61.146	-139.337	27.4	-16	3
YPS-262	4508	100	0	0	0	6	0.7	0.7	323.34	61.417	-140.303	23.8	-17.9	1
YPS-263	4025	91.36	0	0	0	2	0.7	0.7	232.24	61.492	-140.369	12.2	-17.9	4
YPS-264	4147	97.91	0	0	0	4	1.2	0.7	230.52	61.517	-140.317	25.7	-16	1
YPS-265	3553	94.37	0	0	0	0	0.1	0.6	354.78	61.587	-140.179	25.4	-20.9	4
YPS-266	4337	100	0	0	0	5	1.2	0.7	319.18	61.489	-140.029	27.7	-16	3
YPS-267	4022	95.01	0	0	0	5	0.1	0.4	334.96	61.675	-140.063	18.9	-21.9	5
YPS-268	3645	87.6	0	0	0	6	0.1	0.4	333.36	61.696	-140.124	28.6	-21.9	2
YPS-269	3441	73.72	0	0	0	6	0.1	0.6	387.91	61.618	-140.306	15	-20.9	5
YPS-270	3848	61.82	0	0	0	2	0.1	0.6	51	61.716	-140.51	56.8	-20.9	4
YPS-271	2306	2.66	5.1	0	0	4	1.2	0.4	240.76	61.768	-139.638	27.3	-15.7	1
YPS-272	2299	52.02	3.32	0	0	2	0.7	0.5	341.5	61.811	-139.738	26.1	-18.1	4
YPS-273	2250	28.89	0	0	1.21	7	0.7	0.5	379.83	61.904	-139.864	11.6	-18.1	2
YPS-274	2575	14.36	0.24	0	0	5	0.9	0.8	304.7	61.926	-139.446	16.1	-15.6	4
YPS-275	2395	9.13	1.31	0	0	5	1.1	0.6	388.08	61.901	-139.539	28.2	-15.7	4
YPS-311	2342	6.1	25.3	24.3	2.9	7	0	0	364.8	61.349	-135.806	33.4	-21.9	5

Site	Alt. (ft)	Landcover - Alpine	Landcover - Forest	Landcover - Unregen Forest	Landcover - Wetland	Substrate Class	Rain JAN	Snow JUN	Stream density (m /km2)	Latitude	Longitude	Average Channel Depth	Temp Max JAN	Group
YPS-312	3636	96.7	0	0	0	8	0.9	0.8	333.9	61.314	-138.186	27.2	-15.6	5
YPS-313	3561	94.7	0	0	0	7	0.9	0.8	319.9	61.316	-138.31	48.4	-15.6	4
YPS-318	3172	22.3	43.4	7.3	13.8	6	0	0	321.6	61.982	-136.917	20.8	-21.9	2
YPS-320	2830	51.1	39.6	1.2	0.9	7	0	0	305.3	61.438	-134.374	41.8	-16.3	2
YPS-327	2309	9.2	39.3	24.9	2.8	8	0	0	330.4	61.297	-136.151	16.3	-21.9	4
YPS-328	2679	43.6	5.8	0	0.8	6	0	0	281.2	61.671	-136.386	44.2	-21.9	2
YPS-329	2850	28.7	28.4	11.3	5	8	0	0	491.7	61.861	-136.386	38.4	-21.9	4
YPS-330	2538	12.5	75.7	0.4	1.5	5	0	0	325.9	62.046	-136.509	27.8	-21.9	2
YPS-276	1781	27	0	0	0	1	0	1.3	249.97	66.878	-139.136	74	-27.2	4
YPS-277	1801	3.57	66.76	0	0	6	0	1.3	320	66.787	-139.566	30.4	-27.2	4
YPS-278	1991	43	57	0	0	4	0	1.3	340	66.872	-139.531	38.8	-27.2	4
YPS-279	2139	61.1	38.86	0	0	4	0	1.3	310	66.896	-139.616	30.2	-27.2	5
YPS-280	2129	99.92	0	0	0	4	0	1.3	310	66.938	-139.905	35.5	-27.2	4
YPS-281	2136	87	13	0	0	7	0	1.3	270	66.934	-139.901	29.8	-27	4
YPS-282	2303	0	0	0	0	6	0	2.7	270	67.598	-137.388	13	-22	4
YPS-283	1010	34	0	0	0	0	0	2.7	330	67.556	-136.777	51.2	-22	4
YPS-284	984	0	0	0	0	4	0	2.7	460	67.541	-136.741	44.2	-22	4
YPS-285	1460	31.4	0	0	0	7	0	2.7	210	67.525	-136.581	12.6	-22	4
YPS-286	1152	24	0	0	0	4	0	2.7	310	67.657	-136.816	58.4	-22	5
YPS-287	2165	47	0	0	0	5	0	2.7	380	67.654	-137.193	17.25	-22	5
YPS-288	2329	53	0	0	0	4	0	2.7	310	67.708	-137.347	22.26	-22	5
YPS-289	2753	100	0	0	0	7	0	2.7	200	67.749	-137.402	14.8	-22	5
YPS-290	1089	100	0	0	0	4	0	1.9	350	68.109	-138.785	18.05	-24.5	4
YPS-291	1119	100	0	0	0	5	0	1.9	400	68.150	-138.675	43.42	-24.5	4
YPS-292	1201	100	0	0	0	5	0	1.9	330	68.204	-138.531	19.3	-24.5	4
YPS-293	1204	100	0	0	0	4	0	1.9	330	68.204	-138.531	7.9	-24.5	4
YPS-294	1214	100	0	0	0	4	0	1.9	400	68.064	-138.435	10	-24.5	5
YPS-295	1083	100	0	0	0	4	0	1.9	390	68.008	-138.69	19.8	-24.5	4
YPS-296	1270	1	0	0	0	6	0	1.9	340	67.788	-138.136	33.2	-24.5	4
YPS-297	1640	18	0	0	0	6	0	1.9	310	67.211	-138.928	33.8	-24.5	4
YPS-298	1709	16	0	0	0	6	0	1.9	260	67.044	-138.981	16.26	-24.9	4
YPS-299	1198	0	0	0	0	1	0	1.9	170	67.169	-138.13	16.6	-24.5	3

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YPS-300	1056	0	0	0	0	1	0	1.9	400	67.045	-138.254	34.67	-24.5	1
YPS-301	1368	0	0	0	0	7	0	1.9	280	67.030	-138.441	22.4	-24.5	4
YPS-376	952	14.69	30.99	0.15	0	5	0.2	0	710.39	64.395	-140.616	17	-22.6	4
YPS-377	1205	0	31.1	0	0	3	0.2	0	878.78	64.390	-140.822	8	-22.6	4
YPS-378	1045	0	45.89	0	0	5	0.2	0	856.56	64.354	-140.81	8	-22.6	4
YPS-380	2402	0	7.26	0	0	5	0.2	0	759.66	63.953	-140.894	20	-22.6	4
YPS-381	2145	0	17.25	0	0	7	0.2	0	739.22	63.848	-140.55	36	-22.6	4
YPS-382	2077	0	0	0	0	5	0.2	0	889.97	63.517	-140.417	23	-22.6	4
YPS-383	1879	0	0	0	0	5	0.2	0	817.39	63.483	-140.13	30	-22.6	4
YPS-384	1308	0	0	0	0	5	0.2	0	824.08	63.609	-140.04	23	-22.6	4
YPS-385	1915	0	0	0	0	1	0.2	0	1002.52	63.461	-139.232	22	-21.8	4
YPS-386	1063	10.1	85.05	3.45	0	7	0.2	0	806.43	64.025	-139.574	24	-21.8	4
YPS-135	2275	14.66	85.34	0	0	5	0	0	310.33	63.794	-134.696	27	-21.9	4
YPS-400	2390	81.72	0.93	0	0.27	5	0	0.2	747.51	60.113	-136.928	48.8	-17.4	4
YPS-401	2271	44.02	21.78	0	1.12	4	0	0.2	733.52	60.285	-136.998	71.5	-17.4	2
YPS-403	2673	0	0	0	0	5	0	5.5	435.11	60.674	-137.365	43.6	-19.2	4
YPS-405	2948	29.75	5.86	0	0.38	5	0	1.2	779.88	60.872	-133.407	41	-22.4	4
YPS-406	3262	41.72	0	0	1.48	6	0	1.2	596.94	60.895	-133.332	37.4	-22.4	4
YPS-408	2989	50.51	7.51	0	0	6	0	1.2	559.18	60.772	-133.19	30.2	-22.4	4
YPS-409	2291	37.18	14.14	0	0.32	5	4.4	3.2	545.51	60.834	-136.831	17.4	-9.2	4
YPS-410	2594	27.93	14.65	0	0	6	0	0.7	791.64	62.290	-137.295	19.2	-23.1	4
YPS-415	2200	45.34	26.3	0	0.12	6	0	2.6	2240.38	59.843	-135.006	58.8	-19.6	4
YPS-416	2355	7.76	40.96	0.09	0.55	6	0	-0.1	984.61	62.162	-133.272	14.9	-22.4	4
YPS-418	2480	26.11	9.74	0	7.6	4	0	-0.1	856.21	62.005	-132.677	12.3	-22.4	4
YPS-419	2811	42.77	15.58	5.79	4.15	5	0	5.5	789.61	60.923	-137.882	20.2	-19.2	5
YPS-420	2119	12.32	63.08	0	6.23	5	0	5.5	623.45	60.796	-137.672	19.2	-19.2	4
YPS-324	3005	0.616	0.515	0	0.056	1	0	0.1	321.41	61.964	-137.285	48.33	-22.7	4
YPS-345	2135	0.016	0.336	0.637	0	1	0	0	279.17	63.799	-137.687	19	-21.4	4
YPS-346	3477	0.75	0.145	0	0	3	0	0	246.88	63.859	-137.148	16.67	-21.9	5
YPS-349	1361	0	0.966	0	0	2	0	0	353.9	64.042	-138.884	24	-22.5	4
YPS-350	1509	0	1	0	0	2	0	0	287	63.958	-138.711	12.33	-22.5	4
YPS-371	3090	0.571	0.317	0.01	0.004	6	0	0	298.68	61.416	-134.23	37.2	-16.3	1

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YPS-374	2380	0.123	0.44	0.015	0	2	0	0	423.5	61.519	-134.474	27.33	-21.9	4
P1A	4020	6.04	79.31	15.45	0	5	0	0.1	1237.3	62.052	-137.122	6	-22.7	n/a
P2A	4170	6.55	80.92	13.4	0	3	0	0.1	1147.3	62.054	-137.133	19.5	-22.7	n/a