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HYDROLOGICAL GUIDELINES FOR WATERPOWER PROJECTS

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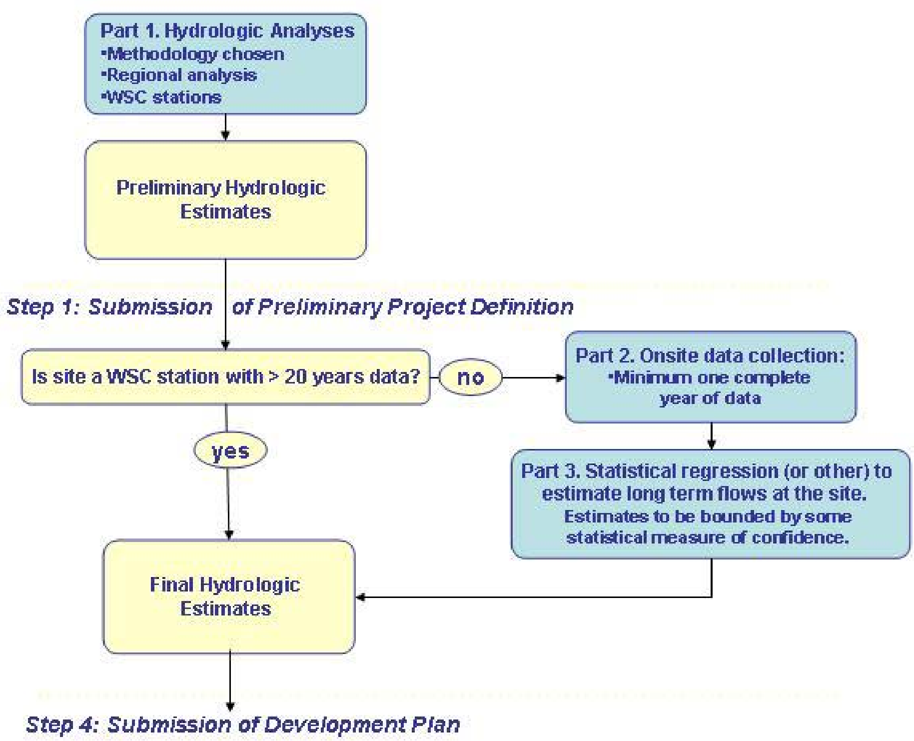
INTRODUCTION

The following guidelines identify methodologies recommended by Land and Water BC Inc. (LWBC) for hydrological data collection and analysis.

Every potential Water Power Project (WPP) site will have its own specific challenges, be it limited long term streamflow information with which to conduct a regional analysis, or poor site options for setting up a hydrometric station. As a result, a prescriptive approach is avoided in these guidelines, rather, the focus is on deliverables for decision making. To achieve these deliverables, recommended best practices are provided. It is left to the discretion of the hydrological consultants to customize both the data collection program and the data analysis methods in order to obtain quality hydrological data and reliable hydrological estimates.

The structure of the hydrological guidelines is illustrated in the flow chart below. Note that the relevant Waterpower Guidebook steps have been superimposed on the flow chart for context:



Part 1 of the guidelines provides information relevant to preparing a preliminary hydrological estimate, a key component of the Preliminary Project Definition (see Step 1 in the LWBC Waterpower Guidebook). Here, selection of appropriate regional stations and recommended best practices are described. At this stage, no site specific data will normally

exist, and therefore hydrological estimates are based on regional records. However there are exceptions to this rule, if for example the selected site has an established Water Survey of Canada (WSC) hydrometric station or the proponent has already set up a hydrometric station and collected a years worth of data. In situations such as these, Parts 1 and 2 may be bypassed and final hydrologic estimates made.

Part 2 provides information relevant to setting up a hydrometric station and collecting flow data. This section describes the challenges associated with establishing a hydrometric station, and presents the current provincial standard for hydrometric surveys. The recommended best practices and deliverables in support of a flow measurement program are provided.

Part 3 is focused on data analysis techniques required to refine a preliminary regional hydrological estimate using site specific data. Reference is made to specific tools that may be useful in refining a hydrological estimate, and deliverables are presented.

The deliverables described in Part 1 are to be included within a Preliminary Project Proposal.

Deliverables outlined in Parts 2 and 3 are to be included within the Development Plan submitted to LWBC in support of a Water Power Project proposal.

PART 1 – PRELIMINARY ESTIMATE

A reliable hydrological estimate is one of the key components of a Preliminary Project Definition. The recommended best practices and key deliverables in support of a preliminary hydrological estimate are provided in this section of the guidelines. Note that other methods of analysis may be used but must be supported with sufficient documentation and be scientifically defensible. Applications will be rejected and returned to the proponent if it is determined that the hydrological analysis provided in the Preliminary Project Definition is insufficient.

Regional compilation of stations

A preliminary hydrological estimate is generally derived from some form of regional analysis. This requires a regional compilation of all long-term discharge stations monitored by the WSC. The WSC stations selected for a regional analysis should be located within the same hydrologic zone as the proposed project.

A hydrologic zone is defined as an area where hydrologic characteristics are homogeneous and where data collected in the region can be extrapolated to estimate characteristics at ungauged sites to an acceptable degree of accuracy. A set of BC Hydrologic Zones has been defined and published by the Ministry of Sustainable Resource Management, and is available on the web:

http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_report_1002.html

Information on the WSC stations selected for a regional analysis should be summarized in a ***regional station table*** and would include:

- ▲ Years of record
- ▲ Pertinent watershed information at the proposed intake location: Drainage area, mean elevation, aspect, average basin slope, % glacier cover; and
- ▲ Flow statistics: mean annual discharge, mean minimum/maximum daily flow, peak flow (200 year return interval), and 7-day low flow.

WSC stations used in the regional compilation should either be naturalized or not have any substantial licensed flow extraction. Water licence information can be found at the following websites:

http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input
ftp://ftp.env.gov.bc.ca/pub/outgoing/lic_images/

For calculation of flow statistics, the ***most recently certified data from WSC should be used.*** A map illustrating where the WSC stations are in relation to the site of interest should also be included to supplement the information in the table.

Regional analysis

A variety of methods exist for estimating stream flow values based on regional data. The following list of references may be used as guides for the most common regional methodologies:

- Squamish – Howe Sound Water Allocation Plan, May 2002. Land and Water British Columbia, Lower Mainland Region. Digital copies available from LWBC Lower Mainland Region (contact: Kristie Trainor, 604-586-4445, Kristie.Trainor@gems7.gov.bc.ca).

- Chapman Geoscience Ltd. 1999. Guide to Peak Flow Estimation for ungauged watersheds in the Vancouver Island Region. Prepared for the Ministry of Environment, Lands and Parks (Water Management). 35 pp plus appendices.

- Coulson, C.H. (ed.). 1991. Manual of Operational Hydrology in BC. Prepared by the Ministry of Environment, Lands and Parks (Water Management Division, Hydrology Section).

- Obedkoff, B. 2003. Streamflow in the Lower Mainland and Vancouver Island (April 2003). Prepared by the Ministry of Sustainable Resource Management. 19 pp plus appendices.
  Weblink: http://srmwww.gov.bc.ca/appsdata/acat/html/deploy/acat_p_report_1002.html

- Reksten, D.E. 1987. A procedure for regionalization of peak flows in BC. Prepared by the Ministry of Environment, Lands and Parks (Water Management Division, Hydrology Section).

For any form of regional analysis, candidate regional stations will need to be selected from the regional station table. WSC hydrometric stations are typically selected based on key characteristics such as (1) drainage area, (2) mean watershed elevation, (3)physical proximity to the proposed project, (4) proportion of watershed covered by glacier ice, and (5) gauge elevation. Practice has shown that watersheds with similar key morphologic characteristics will have similar runoff and stream flow generation mechanisms.

The 5 characteristics listed have been found to be critical to a sound regional analysis. However it is likely that there are other factors, for example basin morphometry, which may be necessary to investigate. It is left to the discretion of the hydrological consultant to select the characteristics deemed appropriate for the project at hand. A comprehensive rationale should be provided which explains the criteria that were used. The reasons for why certain regional stations were chosen and others were excluded should be clearly outlined.

Deliverables

In a Preliminary Project Definition, the following information should be submitted in support of preliminary hydrological estimates:

▲ A map of regional stations in area of interest (indicate which have been selected for regional analysis, identify proposed project location);

▲ A regional station table summarizing the key basin characteristics and flow statistics for the regional WSC stations;

▲ A comprehensive description of the criteria employed to select candidate stations for regional analysis. This should include a rationale of why certain stations were chosen together with justification for those stations not selected.

▲ A comprehensive description of the methodology used in the regional analysis. A rationale explaining why the current methodology was selected should also be provided.

▲ A discussion of error analysis; this should include a mention of where the under or over prediction would lie in the regional estimates.

▲ The following estimated flow statistics for the point of interest:

- ▲ Mean Annual Discharge
- ▲ Mean Monthly Flows
- ▲ Mean minimum/maximum daily flow
- ▲ 7-day average low flow; 1:5 year 7-day average low flow
- ▲ Peak flow (200 year return interval)
- ▲ Flow Duration Curve - While this is not required it is suggested that a flow duration curve be included to help the proponent determine feasibility of the project at this stage.

Recommended best practices

In order to meet the requirements specified in the deliverables section, the following recommended best practices should be applied:

▲ Stream flow estimates generally need to be placed in the context of climatic trends and prevailing weather systems. Consideration also needs to be given to the possible sources of error associated with stream flow values averaged from multiple regional stations.

▲ During this phase of a project's development, preliminary site visits are typically undertaken. This is a good opportunity to investigate potential locations for an on-site hydrometric station, as one will need to be established shortly after submission of the Preliminary Project Definition. Recommended best practices for selecting a suitable site location can be found in Part 2 of the guidelines.

▲ At a very early stage in the Waterpower application process, it is worthwhile to conduct a preliminary investigation regarding the fish species that may be present in the system. Fishwizard is a co-operative presentation of BC Fisheries and Fisheries and Oceans Canada which can be used to find the most recent information about British Columbia lakes and streams and the fish in them, including salmon escapements, and fish stocking records.
Weblink: http://pisces.env.gov.bc.ca/index.asp

▲ Consideration should be given to sediment transport dynamics in the drainage basin of interest. Sediment sources such as slide-prone areas should be identified, and the potential risk for upslope failures and debris flows to seriously impact or destroy instream works should be assessed. In addition, an estimate of a system's bedload transport may be crucial when considering issues related to the design of instream works
Weblink: http://cgrg.geog.uvic.ca/abstracts/ChurchRegionalThe1989.html

PART 2 – DATA COLLECTION

Establishing an instream flow measurement program is an important step in the investigation of a potential waterpower project (WPP) site. In this section of the guidelines the current provincial standard for hydrometric surveys is presented. These standards provide a framework for the hydrological information a proponent will need to supply to LWBC in support of a flow measurement program.

As every potential WPP site has its own specific measurement challenges, the guidelines presented here are focused on deliverables rather than on prescriptive measures. To achieve these deliverables, recommended best practices are described. However, it is left to the discretion of hydrological consultants to establish the most appropriate stream flow monitoring program to achieve the desired results.

The installation, maintenance and operation of a hydrometric station is expected to follow Resources Information Standards Committee (RISC) standards. The RISC standards provide a variety of options relating to instrumentation and station set up, in order to accommodate natural site-to-site variability. A brief overview of the RISC manual, standards criteria, and data certification process is provided. Alternative discharge measurement methods are also discussed.

Instream flow measurement programs specific to waterpower project proposals are relatively short term (1 to 2 years), with the specific purpose of establishing reliable baseline data with which to correlate to long term records. This requires a relatively intense sampling regime, in order to better capture the distribution of flows. Established standards which relate to sampling frequency, such as those of the WSC, are typically intended for long term flow measurement programs. These standards have been adapted here in order to address the specific challenges encountered in a short term flow measurement program. Best practices guidelines and deliverables are provided.

RISC Standards

The provincial standard for hydrometric surveying is provided by the Resources Information Standards Committee:

> Manual of Standard Operating Procedures for Hydrometric Surveys in BC; Prepared by Ministry of Environment, Lands and Parks, Resources Inventory Branch for the Aquatic Inventory Task Force Resources Inventory Committee, November 2, 1998. Version 1.1

> http://srmwww.gov.bc.ca/risc/pubs/aquatic/hydro/index.htm

The RISC manual prescribes the procedures for the measurement and recording of water level and discharge in an open channel. It describes all aspects of hydrometric surveys including stream reconnaissance, site selection, station design and construction, instrumentation, gauge height measurement, discharge calculation, stage-discharge rating and discharge compilation.

STANDARDS CRITERIA

Table 1 defines the various RISC standard levels and the anticipated tests needed to confirm any data set. ***For the purposes of waterpower project investigations, class A is recommended.***

Table 1. STANDARDS REQUIREMENT CRITERIA

Standard Class	Discharge Rating Accuracy	Number of Verticals	Number of Benchmarks	Water Level	Gauge Accuracy
Class A/RS	<5%	N/A	3	Recorder	2 mm
Class A	<7%	20+	3	Recorder	2 mm
Class B	<15%	20+	3	Recorder	5 mm
Class C	<30%	10+	1	Undefined	1 cm
Approximate Methods	>30%	N/A	N/A	Undefined	2 cm

As shown in Table 1, Class A requires 3 benchmarks, a 2 mm gauge accuracy, and the use of a digital recorder to measure water level. ***At a minimum, water levels should be recorded on an hourly basis as streamflow varies on a diurnal basis.*** However, recording the water level every 15 minutes is preferable and will be more representative. It is recommended that all averages (be they daily, monthly or annual) be from the finest-scale data available.

Sampling Methodology

Rating curves are usually determined empirically by means of periodic measurements of discharge and stage. Established hydrometric stations only require periodic discharge measurements to either confirm the permanence of, or follow shifts in, the rating curve. For example, discharge is measured approximately seven times a year at established Water Survey of Canada stations over an appropriate range of flows. However, new stations require more intensive discharge measurements in order to define the stage-discharge relation throughout the entire range of stage. This is the key challenge for waterpower project investigations working within a one-to-two year timeframe.

A relatively intense sampling program, which addresses both frequency and coverage, is required in order to adequately define flow timing and quantity. Sampling frequency and coverage are closely interrelated concepts: Sampling frequency is defined here as the number of measurements recorded for a specified time period. Sampling coverage is defined here as the range of flows that have been measured, for instance some portion of bankfull width or MAD.

It is difficult to specify sampling coverage *a priori*, particularly with less than one year of data. Therefore in order to achieve reasonable coverage, sampling targets are specified primarily by effort:

- ▲For nival/nival glacial regimes (melt-dominated), discharge measurements should be made on a relatively frequent basis during the period of spring freshet. After peak has occurred, the frequency of discharge measurements may drop. In low flow periods, bi-monthly measurements are acceptable.

- ▲For synoptically-driven regimes (rain-dominated), it is generally more difficult to predict/measure high flow. Therefore the sampling frequency will have to increase in late fall (October – November) in an attempt to capture the peaks associated with the autumn-winter rainy season.

- ▲For streams with transitional regimes, whose hydrological response falls somewhere between nival and synoptic regimes, frequent discharge measurements would be required during both the autumn-winter rainy season and the spring freshet.

In addition the real time streamflow information available at the following website may be used to help determine when it is appropriate to undertake streamflow measurements: http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp

Some variability in the sampling frequency is acceptable and expected. For example, a data point may be identified as an outlier and subsequently thrown out as a result of equipment malfunction. There may also be episodic difficulties in accessing the field site (e.g., road washouts). A lower sampling frequency may be sufficient in melt-dominated streams as it is easier to predict the high flow periods compared to synoptically driven regimes. While there will be some variability in the sampling frequency, ***a minimum of 10 discharge measurements, well distributed through the range of flows, is recommended.***

While discharge measurements should be well distributed through the range of flows***, a priority is placed on precisely defining stage-discharge relations for flows less than 200% MAD***. This should be attainable, as discharge measurements are typically easier to collect during lower flow conditions. While design flows vary from project-to-project, they typically fall within 100 to 200% MAD. Lower flows ultimately determine instream flow requirements and power plant capacity.

There are many difficulties associated with collecting high quality hydrometric data. Selecting an appropriate site to establish the gauging station is of primary importance. ***A poorly chosen site will result in poor data, and require more rigorous analysis and substantially more streamflow measurements.*** Section B.1.3 of the RISC standards describes the ideal characteristics associated with gauging station sites and current metering sections. ***The gauging station should be in reasonable proximity to the proposed intake site.***

Measurement of Discharge

The RISC standards address discharge measurements through cross-sectional current metering, or the use of weirs and flumes. Current metering is best suited to large, low-gradient rivers. Weirs are commonly used in small channels with relatively low flow volume. However, the streams targeted for waterpower projects are typically small and steep. Standard current metering does not perform well in small steep streams, particularly those with a boulder-cascade or step-pool morphology and relative roughness values >1. In streams of this nature, ***dilution methods are recommended***.

The theory for any dilution method is to add a measured quantity of a tracer to the flow and then observe its concentration at a point downstream where it is completely mixed with the flow. The tracer typically used is common table salt, as there is a linear relationship between salt concentration and electrical conductivity. Other dilution techniques use dyes. The salt dilution method compares favorably in accuracy with current metering as a method of measuring streamflow, and appears to be capable of superior measurement precision where in-stream turbulence might interfere with current metering (Hudson and Fraser, 2002).

Dilution methods are easy to apply, economical, and have been well described by several authors (Church and Kellerhals, 1970; Day, 1976; Johnstone, 1988; Elder et al., 1990; and Okunishi et al., 1992). Salt dilution techniques have an upper limit related to the quantities of salt solution that can be effectively mixed and injected. Church and Kellerhals (1970) provide an example where a flow of ~18 m^3/s was measured using 40 L of injection solution. It is important to note that the salt dilution method should not be viewed as a replacement for current metering; the two methods are complementary. It is left to the discretion of the hydrological consultants to select appropriate discharge measurement techniques.

Both RISC and WSC standards do not currently provide guidelines for salt dilution measurements. However, the following methods and operational guides are available on the web:

USGS: Volume 1. Measurement of stage and discharge, Chapter 7 – Measurement of discharge by tracer dilution.
http://water.usgs.gov/pubs/wsp/wsp2175/html/WSP2175_vol1_pdf.html

Alternative methods of flow rating in small Coastal streams http://www.for.gov.bc.ca/rco/research/hydropub.htm

ISO standards are also available for purchase over the web:

ISO 1100-1:1996. Measurement of liquid flow in open channels – Part 1: Establishment and operation of a gauging station.
http://www.iso.ch/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=5611&ICS1=17&ICS2=120&ICS3=20

Extending the rating curve

Shallow flow and low gradients often make it difficult to obtain discharge measurements at very low flows. While it is desirable to extend the low end of the stage-discharge curve to zero flow, the lack of accurate measurements makes it a problematic task. Section F.2.3 in the RISC manual outlines a graphical technique for determining the gauge height for zero flow.

There are many difficulties associated with the measurement of peak flows. In synoptically driven watersheds with flashy hydrological responses, it is often difficult to reach the field in time for the peak. For WPP flow measurement programs, the prime limiting factor will most likely be the short timeframe involved. In a one or two year period, it is doubtful that flows as large as bankfull discharge will be captured, and as a result the rating curve will need to be extended.

If there are a reasonable number of discharge measurements, rating curves may be extended by simply plotting the full range of measured discharges against stage on double logarithmic plotting paper. In most cases, the logarithmic plot of measurements will form a straight line in the high flow range, which can easily be extended (see the RISC manual, section F.2.4). The "curve" as determined in the log plot is then transferred to the standard stage discharge plot.

CONFIRMING THE CURVE EXTENSION

Discharges estimated by indirect methods should be used to confirm the high end of the curve extension developed by the log-log plot. The slope-area method is the most commonly used procedure, where discharge is computed on the basis of a uniform-flow equation involving channel characteristics, water-surface profiles, and a roughness coefficient. The slope-area method is commonly used to estimate flow directly after a large magnitude event. This involves the identification of high water marks (see Benson and Dalrymple, 1968).

During a one to two year study period, there is no guarantee that a large magnitude event will occur. In such a situation, the slope area method can also be used to estimate bankfull discharge. This involves the identification of bankfull width, rather than high water marks associated with a specific event. While this is an approximate method, it is most likely a worthwhile endeavour that will better characterize the stage-discharge relation.

Slope-Area Method

Channel reaches lying within the designated station limits should be reconnoitred to find suitable sites for measurements. A minimum of three cross sections are recommended. The fall of the reach should be equal to or greater than 0.15 m (Benson and Dalrymple, 1968). Selected sites should be surveyed and permanently marked:

▲ Evidence of bankfull width, or high water marks, must be clearly evident on both sides of the river.

▲ The reach of river between the cross sections must have similar roughness characteristics

▲ No major tributaries should enter between the measuring site and the point at which the discharge is desired.

▲ The measuring site should be close to the point at which the discharge is desired. It is sometimes preferable to accept less favourable conditions at a site nearer to the gauge.

▲ There should not be any bridges or other "disruptions" to the stream course between the cross sections.

▲ Estimation of bankfull stage should be carried out at or very near to the gauging station. Stage is estimated in order to plot the estimated discharge on the rating curve.

The selection of a suitable reach is probably the most important element of a slope-area measurement. Difficulties commonly associated with the slope-area method in mountain streams include: variable hydraulic characteristics over the reach, estimation of (average) roughness, and supercritical flow. Due to a number of factors, peak flow estimates derived from the slope-area method may not reconcile with the rating curve extension values. If no agreement is found when comparing values derived from graphical curve extension and slope-area computation flow, estimates must be determined based on the judgement of an experienced hydrological consultant.

Deliverables

The following information should be submitted in support of a flow measurement program:

▲ A discussion of the physical setting of the project area, including a description of surficial materials, hypsometry, stream order based on 1:20 000 TRIM maps, drainage area and glacial coverage.

▲ A description of the site (RIC-AQ1) plus photographs of the site at the high and low flow limits of the discharge and stage measurements.

▲ Chronological record of site visits (RIC AQU-06)

▲ Chronological summary of gauge levels checks indicating all applicable gauge corrections (RIC AQU-04)

▲ A fully documented methodology for generation of rating curve and flow estimates.

▲ Rating curve(s):
- ▲ All data points plotted, with dates of measurement
- ▲ Axes scaled to bankfull discharge, or the highest recorded discharge (whichever is greater)
- ▲ Curve(s) identified with number and period of use

▲ A spreadsheet summary (RIC AQU-05)

▲ A chronological plot of percentage departures of the measured discharges from the rating curve values.

▲ A flow duration curve.

▲ Quantitative estimates of error and bias. A discussion on measurement errors/biases should also be provided.
- ▲ Measurement error can be quantified through the replication of measurements.
- ▲ Measurement replication should be repeated if different equipment is used at different levels of stage.
- ▲ Errors associated with the slope-area method are primarily related to site selection. A full discussion of site selection criteria for the slope-area method is presented in detail by Benson and Dalrymple (1967).

▲ List of equipment used for the project, including make, model and calibration dates of sensors, dataloggers, and meters.

▲ An appendix containing:
- ▲ Raw data in graphical form
- ▲ Copies of original gauging notes and level check notes

Recommended best practices

In order to meet the requirements specified in the deliverables section, the following recommended best practices should be applied:

▲ Site selection is paramount to ensuring quality data is collected. A good gauging station site includes (but is not limited to) the following characteristics:

- ▲ Straight, aligned banks
- ▲ Good current meter measuring sites, (e.g. single channel, no undercut banks, minimal obstructions, no turbulence, no slow-moving pools (deadwater), no eddies).
- ▲ Reasonable means of access.
- ▲ No tributaries between gauge and metering sites.
- ▲ No swamps downstream or in vicinity of gauge

▲ Discharge measurements should be carried out over a wide range of flows in order to construct/calibrate the rating curve. A minimum of 10 discharge measurements, ***well distributed over the range of flows***, is required.

▲ In small, steep, turbulent streams, dilution methods are recommended for measurement of discharge.

▲ Class 'A' RISC standards are recommended (3 benchmarks, 20+ verticals, digital recorder, and 2mm gauge accuracy). Level surveys should be completed a minimum of 2 times per year, in order to ensure the gauge has not moved.

PART 3 – FINAL ESTIMATE

This section of the guidelines is focused on LWBC's information requirements at the Development Plan stage of the Waterpower application process. Prior to submitting a Development Plan to LWBC, the preliminary hydrological estimates provided in the Preliminary Project Definition must be refined, and further hydrological information must be gathered. It is assumed that at this point in time a minimum of one years worth of on-site hydrometric data is available.

All of the deliverables outlined in Part 1 of the guidelines are required here, in addition to some further data requirements. Based on the new on-site data available, Part 1 deliverables may or may not need to be refined at this stage.

On-site vs. regional data

The first step is to compare the collected on-site data with the regional flow estimates. The unit runoff value derived from the on-site data should be evaluated against the regionally derived value. At this point in time, a regression analysis with concurrent data from a long term WSC station located in the same hydrologic region is also recommended to assess the fit of the data collected. The goal is to quantitatively compare the on-site data with the WSC station(s) that will be used to synthesize daily flows at the proposed intake site. The method need not be regression analysis, however the approach used must be professionally/scientifically defensible.

If the on-site data deviates significantly from the preliminary regional estimate, it may be necessary to revisit the criteria that were employed to select candidate stations for the regional analysis. Differences between the on-site and regional estimates may also be attributed to problems with the hydrometric station. Regardless of the source, all discrepancies need to be identified and resolved at this point in order to derive a final hydrological estimate. This may be an iterative process, with fine-tuning required at every step in the hydrological analysis.

Deliverables

The following information should be submitted in support of a final hydrological estimate in the Development Plan:

▲ A map of candidate long-term WSC stations in area of interest (indicate which have been selected for regional analysis, identify proposed project location);

▲ A regional station table summarizing the key basin characteristics and flow statistics for the regional WSC stations;

▲ A comprehensive description of the criteria employed to select candidate stations for regional analysis. This should include a rationale of why certain sites were chosen. Justification should also be provided for those stations not selected.

▲ A comprehensive description of the methodology used in the regional analysis. A rationale explaining why the current methodology was selected should also be provided.

▲ A discussion of error analysis; This should include mention of where prediction may deviate from simple averaging of the stations selected for the regional analysis.

▲ The following estimated flow statistics for the point of interest:
- ▲ Mean Annual Discharge
- ▲ Mean Monthly Flows
- ▲ Mean minimum/maximum daily flow
- ▲ 7-day average low flow (Annual, 5, 10 and 20 year return interval)
- ▲ Peak flow (200 year return interval)

▲ A formal comparison (quantitative) of the various unit runoff values derived, and ideally an estimate of the confidence interval associated with the final value that is used to synthesize daily flows and create Flow Duration Curves.

▲ Monthly flow duration curves (both natural flow and diverted plant flow should be identified)

▲ A comprehensive explanation of any correction factors applied to the candidate WSC station(s) to create the Flow Duration Curves.

▲ A plot of the collected on-site daily data superimposed on the concurrent daily discharge supplied by the candidate WSC station(s).

▲ A regression analysis or other that quantitatively defines the degree of relation between the collected on-site data to the candidate WSC station(s).

▲ Summary table and plot of mean monthly flows for the 5-, 10- and 20-year Dry and Wet Return Periods.

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