Hydroelectric Power Planning
DIRECTIVE WORK PLAN

May 2014

Yukon Development corporation

Yukon Government

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Recently, the Minister of Energy Mines and Resources stated "A substantial increase in Yukon's power supply will be necessary over time to foster responsible and sustainable economic development in the territory" and " Hydroelectric power will meet this demand and ensure Yukon's power supply is from a clean, affordable source."

***MW = megawatt**; a measure of capacity to generate electricity. GWh = gigawatt hour, a measure of the amount of electricity generated; one GWh of electricity is roughly how much electricity is consumed by 100 homes in one year.*

INTRODUCTION

It is time for bold leadership to take charge of our energy future so that the next generation of Yukoners will be able to continue to enjoy the benefit of affordable and reliable hydroelectricity. For this reason, the Yukon government has issued a Hydroelectric Power Planning Directive (the Directive) and has asked Yukon Development Corporation (YDC) to develop this Work Plan to set the context for discussions that will lead to the business case for Next Generation Hydro. This Work Plan details a process for selecting one or two hydro developments with supportive renewable power and adequate transmission infrastructure that can be built, with the least risks, to meet future Yukon needs (**Next Generation Hydro**).

Yukon's hydro electrical supply is now close to capacity and there is no transmission line connection to another jurisdiction where power can be bought. Therefore, Yukon must plan and develop its own solutions to ensure there is a future supply of electrical energy (energy) – a supply that meets mid-term (10 to 20 years) and long-term (20 to 50 years) needs. Now, over ninety-five percent of Yukon's electrical generation comes from hydroelectric power. The need for new hydro development resides primarily with the expected long-term population growth of the territory[1] which is estimated to rise over 10 per percent from 36,700 (2013) to 40,400 by 2019. And secondarily, hydroelectricity could be used to help replace the use of fossil fuels for space heating and future electrical use by industrial customers and stranded rate-payers[2].

Industrial customers could increase Yukon's greenhouse gas (GHG) emissions extensively if they can only rely on fossil fuels for power generation. Industrial customers tend to be mineral development companies that have projects at various stages of development. When their projects advance to construction, they will require adequate electricity. Future mining developments are expected to need a significant amount of electricity intermittently over the long-term. These types of industrial customers, if connected to the transmission system, could buy hydroelectricity and help pay for new Next Generation Hydro infrastructure. By doing so, industry would reduce some of their GHG emissions associated with on-site fossil fuel electrical generation.

[1] The Yukon Government's 2014 Yukon Economic Outlook medium-term forecast. Population has been increasing each year for 13 consecutive years. This trend is expected to continue.
[2] Ratepayers are the consumers who pay for electricity produced by regulated utilities.

YDC, a crown corporation, is well positioned to address these challenges and lead the Next Generation Hydro conversation with Yukoners. By legislation, YDC is charged with looking at the role of energy[3] to promote the development of Yukon resources on an economical and efficient basis; promoting employment and business opportunities for Yukon residents; assuring a continuing and adequate supply of energy in a manner consistent with sustainable development; and carrying out development directives issued to it by the Yukon Cabinet. In accordance with the *Energy Strategy For Yukon* and the *Climate Change Action Plan* Yukon government has initiated this Hydroelectric Power Planning Directive and tasked YDC "to plan one or more hydroelectric projects to ensure, together with supporting renewable and, to the minimum extent feasible, non-renewable sources of electrical power, for an adequate and affordable supply of reliable and sustainable electrical power in Yukon."

As YDC advances the Next Generation Hydro Project, Yukon's two regulated utilities - Yukon Energy Corporation (Yukon Energy) and Yukon Electrical Company Limited (YECL) will continue their work to meet Yukon power needs. Yukon Energy is a publically owned utility that is responsible for most of the generation and transmission of electricity in the Yukon through three hydro facilities, a small wind facility and fossil fuel generators. YECL is a privately owned subsidiary of ATCO Power and the primary distributor of electricity in Yukon. YECL purchases most of its power from Yukon Energy for distribution with the exception of its Fish Lake hydro facility and the remote communities in which YECL operates diesel generation facilities (Old Crow, Watson Lake, Burwash/Destruction Bay, and Beaver Creek).

Yukon's hydro potential is a direct result of Yukon's geography, which can be favorable for hydropower development, with numerous rivers of different size flowing through our mountainous environments. However, some rivers with the best hydro potential are either located in National Parks or along the Yukon River. These types of projects and others located far from existing or possible future transmission lines are excluded from consideration in the Directive.

Yukon's remaining major rivers are somewhat disadvantaged by geography, as most rivers suitable for medium to large projects lack waterfalls or elevation drops necessary for hydro generation. As well, most Yukon rivers have water flows that are highly

[3] An Order-in-Council in 1993 (07) restricted the Corporation's role to the role of energy as it relates to the economic development in the Yukon.

concentrated over a 5 month period in the summer, leaving winter and early spring flows low. This is the reason why most medium to large hydro projects in the Yukon are not "run-of-river" projects, as they require some form of storage (reservoirs). To compensate for the lack of waterfalls and consistent seasonal flows, hydroelectric engineers look at rivers that have deep incised canyons where a control structure or hydro dam can be located and where there can be storage capacity (ideally, near natural lakes) to limit the extent of flooding.

It is these geological features that form possible projects, as studied and recorded by engineers in many existing reports. Recently, experts have reviewed possible medium to large hydroelectric sites, as detailed in *Yukon Energy's 2009 Large Hydro (Stage 1: Initial Evaluation Draft Report)* (Large Hydro Study) and the *20-Year Resource Plan (2011-2030)* (20-Year Resource Plan). These documents provide a comprehensive review of all hydro sites that have been identified in the Yukon since the 1950s. This Work Plan suggests a re-assessment of some of these sites against the Directive criteria and various transmission strategies to determine the most favorable projects to meet long-term needs.

Information gathered through the review process will be used to inform discussions with all First Nations, with the Yukon public, stakeholders and others. For those First Nations whose traditional territories may be affected, discussions will address the associated possible impacts and benefits. It is expected that when this process is concluded, the YDC Board will recommend options for Next Generation Hydro from which a business case will be developed. This will not be the end of discussions – this is just the first step in a process that is expected to have many different stages (Appendix 3) and that may take 10 to 15 years.

This Work Plan details the approach to be taken, in an approximate time frame of 12 to 18 months, to meet the following requirements of the Directive:

- Evaluate the expected growth in residential, commercial and industrial demand for electrical power in Yukon;
- Plan for scalability, so as to allow for the increase of energy supply over time to meet projected demand growth;
- Assess the project's financial needs and risks, and evaluate options for project financing and financial risk mitigation;

- Determine the anticipated positive and negative socio-economic and environmental effects of the project, and develop specific means of maximizing its benefits, minimizing its adverse effects and mitigating any unavoidable negative impacts;
- Pay particular regard to the impacts on and opportunities for the First Nation or First Nations in whose traditional territory the project may be located;
- Engage with First Nations to explore options for project location and opportunities for partnership in project planning and execution; and
- Consider one or more specific possible locations for the project, taking into consideration the above criteria as well as proximity to the existing and expected future customer base.

CONTEXT

POLICY OVERVIEW

Yukon government has two main pieces of legislation governing electrical energy in the Yukon: the *Yukon Development Corporation Act* and the *Yukon Public Utilities Act*. The *Yukon Development Corporation Act* states YDC is to participate with the private sector in the economic development of Yukon and, in particular, with regard to energy systems and generation, production, transmission and distribution. YDC also owns and can direct its subsidiary, Yukon Energy Corporation. The Yukon Utilities Board's mandate influences Yukon Energy in the following ways:

- issuing orders fixing rates of a public utility;
- prohibiting or limiting any proposed rate change;
- fixing proper and adequate rates and methods of depreciation, amortization or depletion in respect of the property of any public utility;
- fixing standards, classifications, regulations, practices, measurements or services to be observed, provided or followed by a public utility; and
- determining areas that services of a public utility shall provide.

Yukon government has several policies that affect energy planning in the Yukon. The two main policies are the *Energy Strategy For Yukon* (2009) and the *Climate Change Action Plan* (2009)**.** The *Energy Strategy for Yukon* identifies four priorities for energy in Yukon: conserving energy and using it more efficiently; increasing the supply and use of renewable energy; meeting our current and future electricity needs; and managing responsible oil and gas development. A number of priorities related to electricity are listed in the strategy. They concern investment in infrastructure; assessing the feasibility of expanding the Yukon transmission system; strengthening policy for efficiency, conservation and renewable energy; implementing demand management programs; optimizing use of hydroelectricity; and strengthening roles and responsibilities of YDC and Yukon Energy.

The Yukon government's *Climate Change Action Plan* identifies four goals: 1) to enhance our knowledge and understanding of climate change; 2) to adapt to climate change; 3) to reduce greenhouse gas emissions; and 4) to lead Yukon action in

response to climate change. As part of the reducing greenhouse gas emission goal, Yukon government is seeking to lower its own GHG emissions by 20% of 2010 levels by 2015 and to become carbon-neutral by 2020. The *Climate Change Action Plan* recognizes that the electricity sector can be a major contributor to GHG emissions in two ways: off-grid use of fossil fuels to produce electricity and on-grid use of fossil fuels during high-demand periods on the coldest winter days. The Directive addresses this issue by instructing YDC to look at the use of hydro and supporting renewables as a source of future electrical demand and to minimize, as much as possible, the future use of fossil fuels.

The 2011 *Climate Change Progress Report* states the following targets for the Electricity Sector: 1) by 2020, reducing the emission intensity of on-grid diesel power generation by 20%; and 2) by 2016, reducing on-grid electrical energy use through demand-side management programs by 5 GWh. The related actions include: 1) replacing existing on-grid diesel generation with a lower carbon technology; 2) determining the feasibility of a biomass power generation plant; 3) completing and implementing a Demand Side Management Plan; 4) continuing to implement energy- efficiency programs through the Energy Solution Centre; and 5) finalizing a Net Metering Policy and Independent Power Producer Policy. The Progress Report states the following targets for the industrial sector: 1) by 2016, reducing the electrical energy intensity of industrial operations, including mines, which were operating in 2011 by 15%; and 2) by 2014, establishing reporting protocols for stationary facilities emitting over 2.5 kilotonnes of GHGs per year.

In 2013, the government also released its Micro-generation Policy to help diversify Yukon's energy supply. Micro-generation refers to small-scale generation systems used by individuals, small businesses and communities for their own needs and when they have excess power, it can be sent to the grid. Excess power is acquired for $.21/kWh where there is a connection to the transmission system. For off-grid systems, the price is $.30/kWh. Yukon micro-generation customers outside of municipal boundaries can apply for up to 25 percent of the assessed property value in funding through the Rural Electrification and Telecommunications Program.

The government will also be releasing an Independent Power Production Policy for larger scale generation of electricity that can be purchased by the utilities under certain conditions.

YUKON'S CURRENT ENERGY SITUATION

Yukon Energy is an arms length public utility established in 1987 to provide Yukoners with electricity by both generating and distributing it, or by generating and selling it to Yukon Electrical Company Limited (YECL) to distribute. Yukon Energy distributes directly to 1,700 customers in Dawson City, Mayo and Faro. Yukon Energy has 132 megawatts of power capacity of which 92 megawatts is hydro; the remaining is fossil fuel. Three hydro facilities with the following capacity are located in the Yukon; Whitehorse has 40 megawatts, Aishihik has 37 and Mayo has 15 megawatts. As well, there are two wind turbines with .8 megawatt capacity combined. A transmission grid system connects all the facilities and includes all Yukon communities except for Watson Lake, Burwash Landing/Destruction Bay, Beaver Creek and Old Crow. For those customers connected to the transmission grid, over 95 percent of their power is hydro-generated. Diesel is only used to generate electricity at peak points in the day during very cold winter temperatures. YECL has a small hydro facility with 1.3 MW installed capacity and fossil fuel generators.

In 1949 the first "modern" hydro facility was built in the Yukon at Fish Lake which supplied 230 kW to the Whitehorse area. In 1951, a second hydro facility was built at Mayo to supply 5 megawatt hydro power to United Keno Hill Mine at Elsa. In 1958, a two turbine Whitehorse Rapids hydro facility was built to supply power to Whitehorse. A third turbine was added to this facility in 1969 and a fourth in 1985. The Aishihik facility was built in 1975 to support Faro (a lead-zinc mine) and in support of growth in the Whitehorse area. Northern Canada Power Commission (NCPC) owned these facilities until the assets were transferred from this Federal body to the Yukon Government in 1987.

There are currently four hydro generating stations in operation in the Yukon, as presented in Table 1.

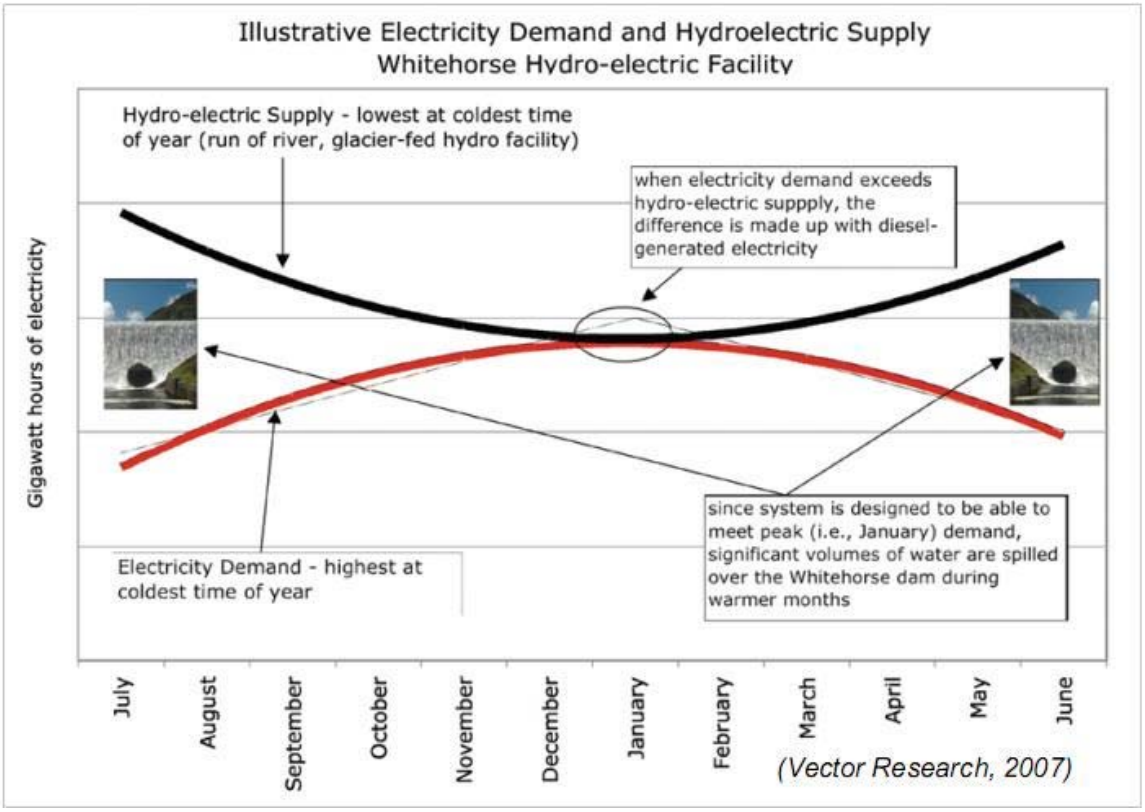
Table 1 Existing Hydro Facilities

Facility	Installed capacity (MW)	Annual Energy Generation (GWh)
Whitehorse	40	245
Aishihik	37	110
Mayo	15	76

Fish Lake	1.3	7
TOTAL	**93.3**	**438**

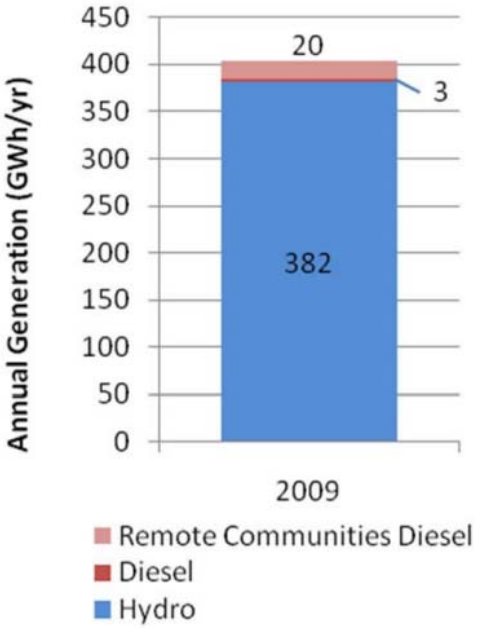
Diesel generators[4] are used for backup and are usually operational on the main transmission grid during peak hours on very cold winter days or when hydro facilities are being maintained (Figure 1). Remote stranded (off transmission grid) communities are also powered with diesel (Figure 2).

Figure 1. Hydro electricity supply changes by month.



[4] Yukon Energy is in the process of seeking licenses to replace two aging diesel generators with natural gas generators.

Figure 2. The chart indicates the GWh/yr source of power by transmission grid hydro, on transmission grid fossil fuel and off transmission grid fossil fuel generation in 2009.



Future diesel (fossil fuel) use was estimated in Yukon Energy's recent application for an Energy Certificate and an Energy Operation Certificate for their Natural Gas Conversion Project. The customer default fossil fuel use on the transmission system is estimated as follows: 2013 11GW.h, 2015 17 GW.h, 2020 41 GW.h, 2025 47 GW.h, and 2030 92 GW.h. These numbers are based on long-term average hydro and wind generation, as it exists today. Load changes and future near- and mid-term renewable projects like hydro enhancement could change these estimates.

YUKON'S CURRENT TRANSMISSION SITUATION

The Yukon's existing transmission system is an isolated grid, which means that it is not connected to any other jurisdiction's transmission system. Up to 2011, the Yukon had two separate transmission systems: the Dawson-Mayo grid that was mainly powered with the Mayo Generation Station, and the Whitehorse-Aishihik-Faro grid that was mainly powered with the Whitehorse and Aishihik generation stations. In 2011, the construction of a new transmission line between Carmacks and Stewart Crossing was completed linking the two grids into a single Yukon transmission system. Yukon Energy

can now manage the system as one integrated unit to optimize the use of renewable hydro resources[5].

Based on current load and projected growth, the existing transmission system will accommodate ratepayer growth for the foreseeable future. Enough load growth anywhere on the existing grid would require upgrading of its capacity. Large industrial customers and or a jurisdictional transmission link will require new transmission infrastructure. The location of a new hydro project, and the required transmission to connect to Yukon loads and new or anticipated customers, will be an important consideration. The associated costs will likely be a major consideration in the business case.

Yukon's stranded transmission system could benefit from an interconnection with the North American transmission system through British Columbia or with Alaska (Southeast or main). The most likely interconnection options appear to be the following:

1) Interconnection with British Columbia (BC)

   BC Hydro is currently completing the construction of the Northwest Transmission line. It is a 287 kV transmission line extension running from Terrace to Bob Quinn Lake along the Stewart-Cassiar Highway (Highway 37). An extension to the line will be built by Imperial Metals to just south of Iskut to connect with their Red Chris Mine. The transmission line will then reach a point approximately 340 km south of the Yukon border. Once completed, this portion of the line will be acquired by BC Hydro.

   Approximately 800 km of new transmission line would be required to connect the new line with Whitehorse or Faro.

2) Interconnection with Skagway, Alaska

   A Memorandum of Understanding (MOU) was signed in the fall of 2013 between the Yukon government) and the State of Alaska to study the feasibility of linking

[5] As of today, only four communities in the territory are not connected to the grid: Watson Lake, Destruction Bay, Burwash Landing and Old Crow.

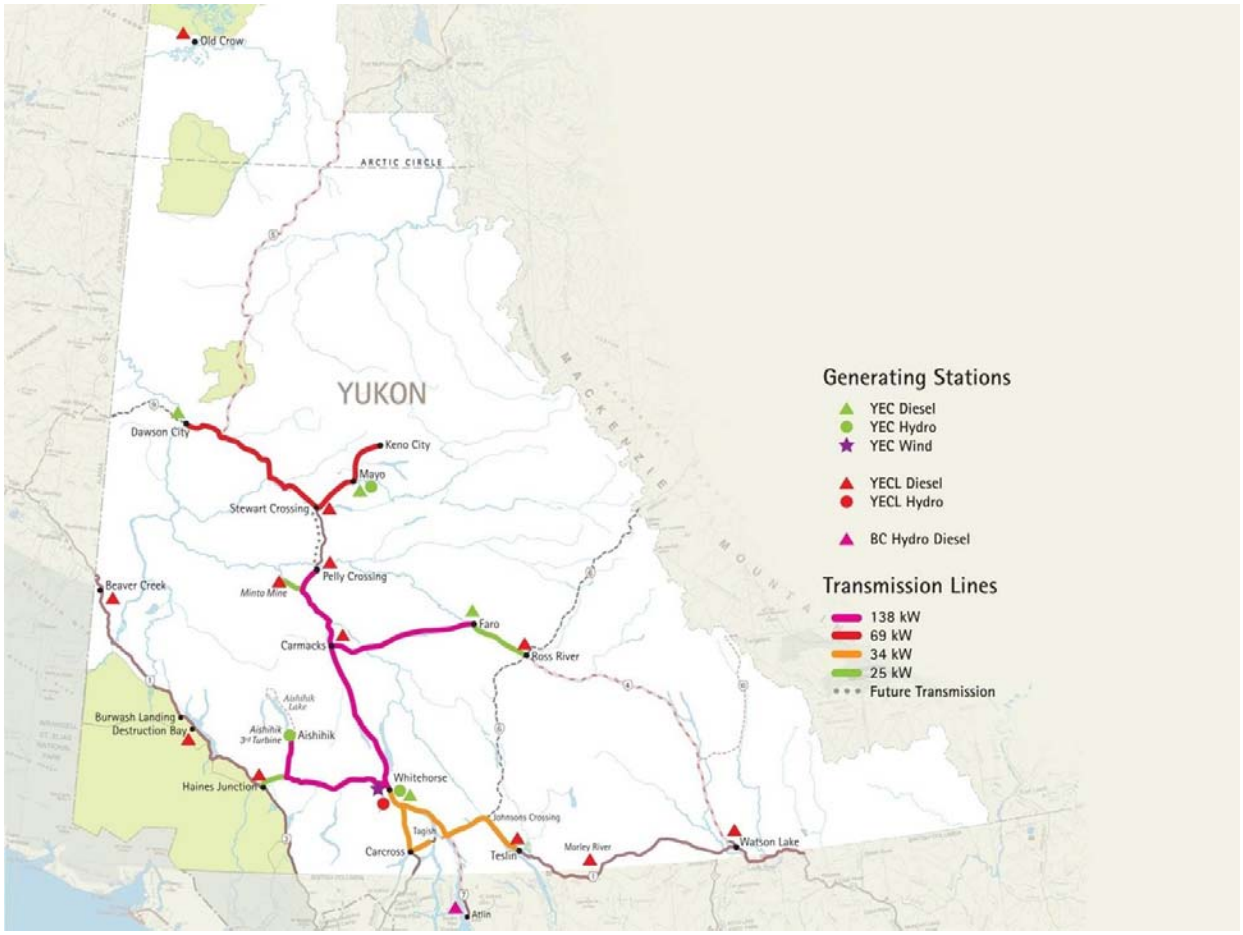
Skagway and the Yukon grid. Yukon government recently commissioned work to look at a Viability Analysis of a South-East Alaska and Yukon Economic Development Corridor.

Alaska Power & Telephone has filed for a Federal Energy Regulatory Commission Preliminary Permit for West Creek Hydro in Dyea to determine if the project is economically viable and timely. The West Creek Hydro project is estimated to have 25 MW capacity potential. A potential interconnection could benefit both jurisdictions. Power from a new generating station (West Creek or other) could be utilized in the summer by Skagway (cruise ships) and by the Yukon during the winter months. A new transmission line would also open the door for new hydro developments in this corridor. Approximately 160 km of new transmission line would be required.

3) Interconnection with mainland Alaska, towards Anchorage and/or Fairbanks

A new transmission line towards the main cities of Alaska could potentially provide some benefits to Yukon. The State of Alaska is currently looking at developing the Susitna Hydro Project near Denali Park and it likely has growing energy needs. The distance to travel between the two grids is in the range of 800 to 1000 km.

Figure 3 - The Yukon power system.



JURISDICTIONAL OVERVIEW

The Government of Northwest Territories' three-year action plan, released in 2013, sets the focus on stabilizing the high cost of power, transmission line expansion, energy efficiency, biomass, other renewables and liquefied natural gas. NWT has 55 MW of hydro electricity and a listed potential of 11,520 MW that could some day be built: Bear 568 MW, La Martre 27 MW, Lockhart 269, Mackenzie 10,450, Snare 33 MW, Snowdrift 1 MW, and Taltson 18 MW.

The Alaska State Legislature passed legislation in 2010 to direct the State to receive 50 percent of its electrical generation from renewable and alternative energy sources by 2025. Alaska has approximately 423 MW of hydro electricity meeting 24 percent of Alaska's present energy needs. To meet their 2010 goal for renewable energy, planning work was started for two hydro projects located in the Railbelt area: Susitna (installed

capacity of 600 MW and 2600 GWhrs annual energy) and Chakachamna (300 MW and 1300 GWhrs of annual energy).

British Columbia Government passed its *Clean Energy Act* in 2010. One of the act's objectives is for at least 93 percent of the electricity generated in BC to come from clean or renewable resources. Clean energy is defined as biomass, biogas, biogenic waste, geothermal heat, hydro, solar, ocean or wind. BC Hydro, the government's crown corporation utility, has 31 integrated hydroelectric stations, two gas-fired thermal power plants and one combustion turbine station for a total installed capacity of 11,000 MWs and 43,000 GWhrs annually. The Site C project, if installed, would place a third dam and hydro generating station on the Peace River yielding 1100 MW of capacity and 5,100 GWh of annual electricity. The *Clean Energy Act* limits BC Hydro to the development of this one site only. Independent power producers have the priority to develop smaller hydro projects throughout the province.

EXPECTED GROWTH DIRECTIVE

The OIC directs YDC to "evaluate the expected growth in residential, commercial and industrial demand for electrical power in Yukon". This Work Plan will assess existing new energy growth forecasts and develop various long-term economic scenarios depicting Yukon's future. As this research is being conducted, conversations will be held with the public, stakeholders and other levels of government.

CONTEXT

Various government agencies, researchers and think tanks have done some work to forecast mid to long-term economic and growth scenarios[6]. For instance, Yukon government puts out an Economic Outlook; this tool assesses present economic indicators and provides a year-out and medium-term forecast. The current February 2014 Yukon Economic Forecast uses a model designed specifically for the Yukon. This model suggests Yukon will expect to reach 11 consecutive years of gross domestic product (GDP) gains by the end of 2014. It also predicts the medium term (2015-2019) period will have a 30 percent higher than 2013 estimated value of GDP. This represents an average annual growth of 5 percent in the medium term. Gains are expected to come from the mineral development sector and, in particular, the following mines: Whitehorse Copper – magnetite (2014), Eagle Gold (2016), Carmacks Copper (2017), and Casino Mine (starting in 2017 but in full production in 2020). Although mines are good electrical customers, they carry the risk of load disruptors. Depending on mineral prices and other factors mines can be forced to slow or stop production until conditions improve.

Yukon Energy's *20 Year Resource Plan* looks to the future from the perspective of demand and supply and the risk to ratepayers for paying for the new electrical demand that might come from a high priced fossil fuel (usually diesel). Population is expected to continue its 13th consecutive year of growth, leading to a population of 40,400 people in 2019. Figure 4 shows the present breakdown of electrical users in KW.h. The majority of sales go to general users listed as wholesale to YECL or as residential or general service to Yukon Energy customers. Possible future demand is shown in Figure 5. This

[6] A number of forecasts are made by different agencies. They include Conference Board of Canada, Yukon Energy (20-Year Resource Plan), Yukon Government Climate Change Secretariat, and Yukon Government Economic Forecast.

is just one possible long-term maximum growth scenario showing use in GW.h/yr. It indicates what percentage of future demand could be met by Yukon's present hydro generation. Future work will be conducted to look at a variety of long-term scenarios with various assumptions to aid conversations regarding Yukon's future and the associated energy demands.

Figure 4. Yukon Energy's annual sale volumes by customer class.

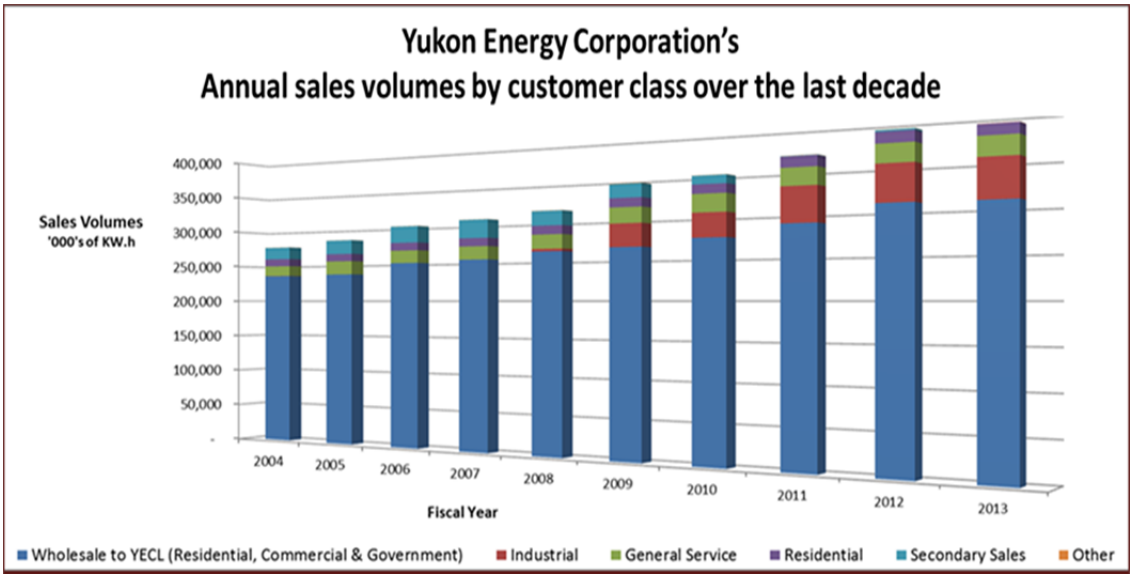
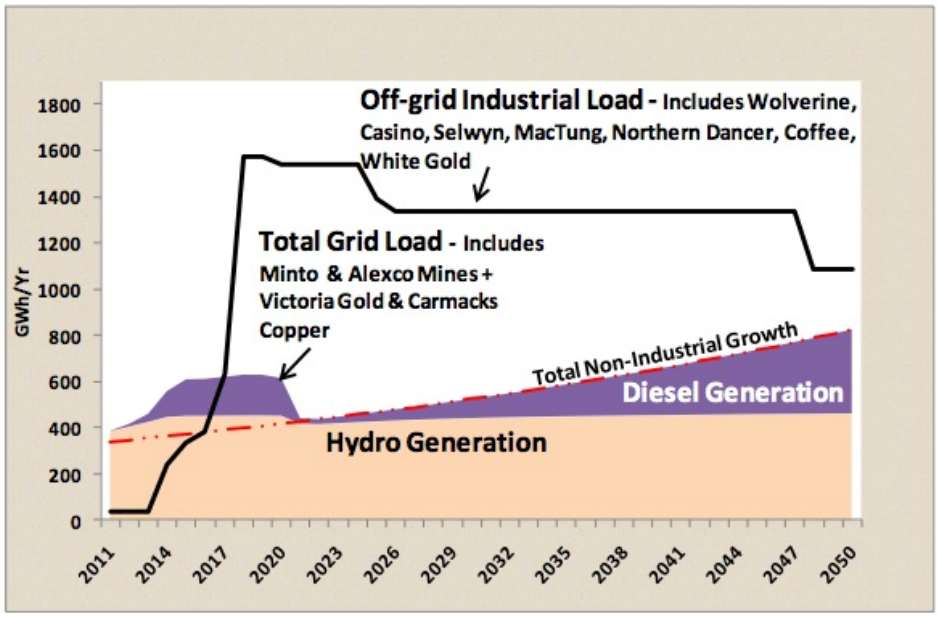


Figure 4 One long-term scenario from Yukon Energy's 20-Year Resource Plan that predict future demand.

Figure 2-4: Existing System Capability to Supply Potential Grid Load & Potential Off Grid Mine Loads: 2011-2050



***Scenario B - Base Case Load Forecast with Victoria Gold, Carmacks Copper & WHCT**

	2011*	2015	2020	2025	2030	2035	2040	2045	2050
Grid Load/Hydro Supply Gap**	2	158	163	40	83	138	204	278	364
(Forecast Diesel Generation-GW.h/yr)									
Potential Off Grid Mines	37	332	1,538	1,390	1,338	1,338	1,338	1,338	1,088
(Forecast Diesel or LNG*** GW.h/yr)									
Total Yukon Diesel or LNG Generation (GWh/yr)	39	490	1,701	1,430	1,421	1,476	1,541	1,616	1,451
Total Potential GHG's (tonnes)	26,962	343,073	864,118	674,435	667,793	706,413	752,282	804,481	689,306

* 2011 diesel generation is based on long term forecast (not actuals)

** Assumes connection of Carmacks Copper and Victoria Gold to grid

***Assumes Casino develops using LNG with combined cycel power generation & other off grid mines develop using diesel

ACTIONS

A Next Generation Hydro and Transmission Viability Options Study will be commissioned to address the key criteria of the Directive and aid in the selection of one or two Next Generation Hydro Project options and related renewable and transmission infrastructure. As this study is taking place, a variety of technical papers will be written for each of the Directive criteria. These technical papers will be shared with First Nation Governments, agencies, stakeholder groups and the public. The Next Generation Hydro and Transmission Viability Options Study will summarize the technical papers and finalize the assessment of the directive criteria. The summary of the engagement process will be written into the **Next Generation Hydro Discussion Paper**. The

combination of these two documents will aid decision-makers in their selection of one or two hydro projects to proceed with business case development.

Technical Paper - Economic Growth Scenarios and Energy Demand Forecasts

This paper will update mid and long-term scenarios using a variety of different assumptions that take into account GHG targets and other related policy considerations. Different economic scenarios will be developed and for each, energy demand forecasts will be constructed. This work will help present Yukoners with scenarios mid- (10 to 20 years) to long term (20 to 50 years) so that discussions can be framed in consideration of future generations.

SCALABILITY DIRECTIVE

Criteria 2 directs YDC to "plan for scalability, so as to allow for the increase of energy supply over time to meet projected demand growth". This Work Plan will explore scalability as a means of mitigating Next Generation Hydro risks. In particular, scalability will be addressed from two perspectives. First scalability will be examined as it relates to medium and large hydro projects that can be built out or added to in stages to increase capacity and energy output (keeping in mind the need to mitigate negative environmental and socioeconomic effects). And secondly, scalability will be achieved through a transmission strategy that leads to an eventual jurisdictional connection. In the latter, the question will be: how can transmission extensions either south toward BC or Alaska make a difference to the selection of Next Generation Hydro projects and other renewable options being considered for business plan development?

CONTEXT

Variations and scalability of hydro options and planning out of mid- and long-term energy and transmission strategies are some of the complex questions that this Work Plan will begin to explore. Yukon Energy's 2009 Large Hydro (*Stage1: Initial Evaluation Draft Report)* (Large Hydro Study) and the 20-Year Resource Plan (2011-2030) (20-Year Resource Plan) provide some insights into the complexity of variation and scalability. For instance, one medium or large hydro project may have several different design options (called variations). Some project designs or variations allow for additional build-outs (scalability options) that could improve the capacity and energy output of the project(s). And, some of these project variations result in more or less negative environmental and socioeconomic impacts.

For example, one project recommended in the Large Hydro Study, Hoole Canyon, could be configured several different ways resulting in installed capacity ranging from 25 to 42 MW. However, Hoole Canyon is only economically viable with upstream storage. There are two choices for this: Fortin Lake or Slate Rapids. Hoole Canyon could, therefore, be built in one of several ways. Each option changes the capacity, power and business case of the Hoole Canyon project.

Scalability can also be looked at from the perspective of transmission strategy. Many hydroelectric and other renewable projects are considered expensive (over 15 cents kW.h) at the moment because each project cost includes the cost of building transmission lines to the main grid. If that transmission line existed, how would the selection of hydro projects change? For instance, if a transmission line were built to Skagway, hydro projects located along the way become more cost-effective. The same is true if the transmission system was built out from Faro towards Watson Lake.

The ultimate transmission strategy leads to a jurisdictional connection. If this were to be achieved, how then would the selection of hydroelectric and other renewable projects in the Yukon change? As an isolated grid, there is no option to sell or buy power from another source as a means of offsetting risk to ratepayers. On an isolated grid, every additional generation project carries the risk of customer loss especially from potential industrial load interruptions. But if planning is too conservative and options are not developed, there is a risk of power deficiencies and the use of fossil fuel generation.

Transmission strategy requires analysis regarding the dynamics of these complex electric systems. An electrical transmission line is used for long distance transfers of power where substations convert power for delivery to distribution grids with shorter links to users. The dynamics between load and power on these systems must be in balance. The more connections a grid has to other grids, the more complex the balancing of load and power generation becomes. For this reason, Yukon's power needs cannot be met simply by connecting to BC with a transmission line. Yukon would still need its own generation to balance out the transmission system's dynamics. Once achieved, jurisdictional transmission would lessen the risk associated with managing Yukon's power surpluses or shortfalls.

ACTIONS

Technical Paper – Scalability of Next Generation Hydro Project Options

This paper will address Next Generation Hydro Project risks by looking at the pros and cons of various hydro projects in terms of their flexibility to be scalable (build-outs and fit to other renewables) and their relative ability to respond to demand forecasts and growth scenarios in the mid- to long-term.

Technical Paper – Jurisdictional Transmission Line Technical Logistics Analysis

This paper will address Next Generation Hydro project risks by asking the question whether strategic investments to extend Yukon's transmission system to another jurisdiction (for instance, from Faro to Watson Lake or Whitehorse to Skagway, Alaska) would make a difference to 1) the selection of Next Generation Hydro options and 2) the ability to scale out energy supply and mitigate industrial load interruption risks. As well, what amount and what location of Yukon based load and supply is required to make a transmission line connection technically feasible (line balancing requirements)?

Technical Paper – Jurisdictional Transmission Connection Market Assessment

This paper will address the business case of jurisdictional connection. What are the market economics associated with a jurisdictional transmission connection (Alaska and BC)? Would other jurisdictions sell power to the Yukon? Would other jurisdictions consider Yukon power affordable and be interested in buying it? If jurisdictional transmission was to be considered viable, how should it be built out and what Next Generation Hydro Projects would best suit this build-out?

FINANCIAL NEEDS AND RISKS DIRECTIVE

Criteria 3 directs YDC to "assess the project's financial needs and risks, and evaluate options for project financing and financial risk mitigation". Any new medium to large hydro project and associated transmission infrastructure will mean hundreds of millions of dollars of investment. This Work Plan will determine estimated overall and per stage project costs that are expected be incurred over a 10 to 15 year period. Financial tools, funds, programs and models will be reviewed by looking at the ways other jurisdictions in Canada have approached and financed projects of a similar size.

CONTEXT

Hydro projects have a high upfront capital cost followed by low operating costs over more than 50 to 100 years. The financial needs and risks of this upfront cost are considered to be "project" costs. Projects are temporary and one-time undertakings that create a product – in this case, a hydro facility with associated renewables and transmission needs. The financials associated with the operation of the facility are an ongoing cost. Project costs can be split to include various stages including conceptual design, prefeasibility, feasibility, planning, construction and operations. Project economics are best described by key components of each stage. For each stage sources of funding and partnership opportunities can also vary.

The Large Hydro Study shows the possible costs (2009 dollars) for a number of potential projects. As an example, one medium sized project with installed capacity of 80 MW could cost up to $934.8 million and one large hydro project with installed capacity of 254 MW could cost up to $1,6 billion. In addition to these capacity costs there will be other expenditures for Impact Benefit Agreements and transmission lines.

Yukon's most recent hydro project, Mayo B, was an enhancement (10 MW) to an existing hydro facility and a transmission project that connected two transmission systems together. The project cost was $120 million; the Federal Government provided $53.5 million of the funding, while Yukon government and YDC supplied $30.14 million and electrical ratepayers 36.5 million. Federal Government funds allowed the project to proceed without negatively affecting ratepayers (called rate shock). This was a necessary intervention, given that Yukon has a very small number of ratepayers (rate

base). And again, we have an isolated transmission system which prevents the ability to purchase power from another jurisdiction.

A Next Generation Hydro project would likely be 8 to 10 times the cost of the Mayo B hydro enhancement and transmission project. For instance, in northern BC near the end of the Northwest Transmission Line, AltaGas is working on three hydroelectric projects (Forest Kerr 195 MW, McLymont Creek 66 MW, and Volcano Creek 16 MW). The Forrest Kerr Project is a 195 MW facility that will divert part of the Iskut River through a tunnel to an underground powerhouse. This project is estimated to cost $725 million. It will be connecting to the transmission grid at Bob Quinn Lake via BC Hydro's proposed 287 kV Northwest Transmission Line.

The economics of Next Generation Hydro Power (with supportive renewables and transmission) would need to be carefully considered. Yukon's borrowing limit is $400 million. Even if that were fully utilized, it would not be enough for a medium to large hydro project with transmission. Best practices from other jurisdictions will be reviewed to determine possible financing models and partnership options that could apply in the Yukon; including tools suited to First Nations investment.

Securing government funding will be highly considered. In particular, a Next Generation Hydro Project's eligibility for one of Government of Canada's infrastructure funds and the ability to access a loan guarantee. Recently, the Federal Government provided Newfoundland a loan guarantee of $6.3 billion in 2012 for Muskrat Falls, a large hydro project in Labrador.

Depending on the project, it is also possible to interest a lending institute and various funding agencies that specialize in renewable energy projects.

ACTIONS

Technical Paper – Project Cost per Hydro Development Phase

This technical paper will address Next Generation Hydro's upfront capital project needs and risks per stage of development. Project costs can be divided over various stages including conceptual design, prefeasibility, feasibility, planning, construction and operations. Financial risk mitigation will be discussed in terms of types of funding models available and the sources of funding and partnership opportunities that exist.

SOCIO-ECONOMIC AND ENVIRONMENTAL EFFECTS DIRECTIVE

Criteria 4 and 5 directs YDC to "determine the anticipated positive and negative socio-economic and environmental effects of the project, and develop specific means of maximizing its benefits, minimizing its adverse effects and mitigating any unavoidable negative impacts" and "in respect to the effects have particular regard to the impacts on and opportunities for, the First Nation or First Nations in whose traditional territory the project may be located." This Work Plan begins this process by first; working with First Nations and then, working separately with interested stakeholders to identify general values so that impacts and benefits can be discussed. As well, conversations will be started on how to minimize impacts and realize benefits for the possible future Next Generation Hydro. These are conversations that will last longer than the time frame of this Work Plan so they will be used to start a pro-active dialogue with YESAB, First Nations governments, stakeholders, the public and regulators on the values that should be assessed if a project were to advance to assessment by YESAB.

CONTEXT

A Next Generation Hydro Project will require a suite of territorial, federal and (potentially) First Nation authorizations. In particular, a hydro project will require a Decision Document pursuant to the *Yukon Environmental and Socio-economic Assessment Act* (YESAA), a Water Licence under the Yukon *Waters Act*, and most likely a *Fisheries Act* Authorization and Fish Habitat Compensation Plan. A number of other project authorizations will also be required (Appendix 2). This is one of the reasons it takes 10 to 15 years to build a medium to large hydro project.

While the Next Generation Hydro Project has not been selected, all sizable energy projects have both positive and negative effects at different project phases (construction, operation) and the project elements (specifically the reservoir, storage and generation infrastructure /facilities, and the transmission line) will have different socio-economic and environmental implications. Preliminary lists of potential impacts are presented in (Appendix 1). A Next Generation Hydro Project will avoid the need to use fossil fuels for electrical generation. Instead, it will use water. This can have both aquatic and terrestrial environmental impacts due to changes to water flows, shoreline erosion, flooding, barriers to fish migration and spawning habitat disturbance. *YESAA* requires

consideration of these adverse environmental effects, including cumulative effects. (The *Yukon Waters Act* and the Canadian *Fisheries Act* will have requirements as well.)

YESAA (Section 42) refers to the need to protect rights of Yukon First Nations under the Final Agreements including First Nation relationships to the wilderness environment. It also mentions the need to address cultures, traditions, health and lifestyles of First Nations and other residents of the Yukon. *YESAA* defines socio-economic effects as "the effect of any change [to the environment] on health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes by Aboriginal persons, or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance".

While hydroelectric projects will offset the GHG from the equivalent consumption of fossil fuel generation, hydro projects can also produce some GHG due to construction and the effects of storage reservoirs. Reservoirs can also cause an increase production and mobilization in methyl mercury. Special consideration to these types of effects will form part of the Work Plan assessment of Next Generation Hydro options.

Conversely, there will be many positive implications of a hydroelectric project. Particularly, it is a source of renewable energy that will support future generations of ratepayers and to some extent future economic opportunities. As well, business opportunities and jobs will result from planning and constructing the project over a 10- to 15-year period.

ACTIONS

Technical Paper – Positive and Negative Socio-economic and Environmental Effects of the Project

This technical paper will address the possible positive and negative socio-economic and environmental effects of a medium to large hydro project and related infrastructure. Specifically, it will address best practices for maximizing benefits, minimizing adverse effects and mitigating any unavoidable negative impacts. As well, this technical paper will address best practices regarding effects that might have particular impacts on and opportunities for, the First Nation or First Nations in whose traditional territory the project may be located. Important values that will be affected by a hydro project will be noted

and discussed with YESAB so that a comprehensive and pro-active approach can be taken to the assessment of a potential future project.

ENGAGE WITH FIRST NATIONS FOR PROJECT LOCATIONS AND PARTNERSHIPS DIRECTIVE

Criteria 6 directs YDC to "engage with First Nations to explore options for project locations as well as opportunities for partnership in project planning and execution". The Work Plan begins this process. First Nations will be partners in future hydro and other renewable energy development in the Yukon. Information will be shared with First Nations to explain Yukon's energy situation and how hydro, other renewables and transmission projects might fit into future economic growth scenarios. Where a potential medium to large hydroelectric project exists in a First Nation traditional territory, the directly affected First Nation will be more formally consulted. YDC will work with the affected First Nation to develop a mutually agreeable engagement protocol. This will include meetings with the Elder Council, Chief and Council, citizens, agencies and government officials.

CONTEXT

Common Law considerations now in effect have established that the Crown should begin to engage or begin consultation as soon as possible for a possible project to ensure Treaty, Aboriginal and Settlement Rights are addressed and the affected First Nation can later be accommodated accordingly. Accommodation between the proponent and the First Nation government is usually described in an Impact Benefit Agreement (IBA). These agreements discuss issues related to harvesting rights, traditional activities and heritage sites, training and employment. A separate process is usually set up, often with the First Nation development corporation, to discuss and negotiate investment or business partnerships.

In addition to Common Law, Yukon also operates according to the Umbrella Final Agreement (UFA). This was a framework set up in 1993 to enable the negotiation of land claims in the Yukon. For the First Nations who have a UFA land claim, Chapter 22[7] (Schedule A) indicates that a First Nation may participate with the proponent (the Yukon, or agency or corporation of the Yukon - like YDC) in economic opportunities including, but not limited to, joint ventures, partnerships and equity participation in subsidiary

[7] There are a number of other chapters of the UFA that deal with land tenure aspects of possible future hydroelectric projects (Chapter 7, Chapter 5, access chapter).

corporations. Each individual land claim agreement indicates, in more specific detail, how each First Nation might invest in power projects. For instance, the Na-cho Nyak Dun (ND) Final Agreement Strategic Investments section states that the First Nation can acquire up to 25% of the interest of the Proponent's (YDC) share of the project.

YDC and First Nations have entered into investment agreements for a number of Yukon Energy projects. In 2000, Yukon Energy initiated the Mayo to Dawson City transmission line project, which was completed in 2003. The project crossed through two Yukon First Nation Traditional Territories[8] (those of Na-cho Nyak Dun and Tr'ondëk Hwëch'in). Tr'ondëk Hwëch'in First Nation participated as project investor. In 2008, Yukon Energy began work on Mayo B, an addition to an existing hydro facility, within the Na-cho Nyak Dun Traditional Territory. The project was completed in 2011 and it included an investment by Na-cho Nyak Dun First Nation.

In terms of hydroelectric sites, the UFA allows for 10 sites to be noted. As not all the Yukon First Nations have settled land claims, 6 of 10 sites have been designated as protected by notation: Teslin (Morley River), Champagne Aishihik (Aishihik, Long Lake, Hutshi Creek and Gladstone), Tr'ondëk Hwëch'in (North Fork), Selkirk (Granite Canyon), Na-cho Nyak Dun (Hess River) and Kluane (Gladstone Lake). In Kaska Traditional Territory, a number of other possible sites exist and are discussed in the Large Hydro Study. A number of First Nations are also pursuing their own interests in energy including Liard First Nation (LFN). Together with the Town of Watson Lake and Yukon Electrical Company Limited, LFN recently released a report looking at hydroelectric opportunities in South East Yukon.

In 2011, Yukon Energy, Yukon Indian Development Corporation Ltd. and the Council of Yukon First Nations organized and held the Yukon First Nation Energy Forum. At the Forum the groundwork was laid, to forge a common understanding and collaborative path forward between First Nations and Yukon Energy with regards to short and longer term electrical needs. Collaboration was recognized, as the way to learn and build common knowledge with regards to future electrical needs facing Yukon.

[8] The Access Chapter of the UFA sets out the rights, obligations, terms and conditions under which undeveloped settlement lands may be accessed or utilized. Chapter 5 of the UFA addresses tenure and management of settlement lands and future areas for hydroelectric and storage water projects is discussed.

ACTIONS

Yukon First Nation Energy Forum Part 2

To help inform First Nations leadership, technicians and government officials, YDC will hold an Energy Workshop to continue the conversation started in the first Yukon First Nation Energy Forum. The workshop will re-introduce the energy context, outline the potential for medium to large hydroelectric projects and other renewables, discuss transmission strategies, investment models and opportunities and how impacts to values could be addressed. A technical paper may result from this Forum.

Where a potential Next Generation Hydro project exists, First Nations will be asked to work with YDC to create a meaningful set of engagement activities related to the Work Plan. This will likely include meetings with the Elder Council, Chief and Council, citizens, agencies and government officials. In particular, for potentially qualifying Next Generation Hydro projects, work will begin to identify socio-economic, heritage and environmental values from both a traditional knowledge and scientific perspective.

HYDRO LOCATION DIRECTIVE

Criteria 7 directs YDC to "consider one or more specific possible locations for the project, taking into consideration the above criteria as well as proximity to the existing and expected future customer base". This Work Plan recognizes past legacy hydro and how its development might inform future hydro development. In the past, legacy hydro facilities refer to hydro assets that were developed largely to supply electricity to longer-term mine loads. These facilities are still providing Yukoners with affordable electricity. Planning new Next Generation Hydro will require similar foresight. New hydroelectric projects will need to meet a number of criteria including those outlined in the Directive.

CONTEXT

Yukon, in the mid- to long-term, is expected to see population increases and related expanded commercial and public service activities. Yukon's economic sectors include tourism and culture, agriculture, film and sound, forestry, and innovation and technology. Oil and gas and mining and exploration are also expected to grow. Combined, this growth will drive up the demand for electricity. And as transmission challenges are overcome, there will be opportunities to capture new customer markets like Watson Lake and some share of off-grid industrial projects[9].

A variety of mining projects are at various stages of development (exploration, construction, development, production and reclamation) in the Yukon. Three hard rock mines are operational (Minto, Bellekeno and Wolverine) and a number of other mining projects are likely to move out of assessment and licensing into construction and production in the next ten to thirty years (Whitehorse Tailings, Eagle Gold, Brewery Creek, Carmacks Copper, Casino, Selwyn, Northern Dancer). Other exploration plays show promising trends (Rau Gold, White Gold, Ketza River). Yukon Energy has a load forecast that tracks industrial trends (based on a variety of assumptions to estimate possible future demand scenarios for electrical power)[10].

[9] If the Alaska Highway or other pipeline were ever to be built, there could also be a requirement for power at pump stations.

[10] The Mineral Advisory Board has stated on a number of occasions that access to the electrical grid and limited amounts of reliable and affordable power affects the future of the economy and the mineral development industry.

Mineral development customers with operating mines bring potential benefits and risks. They benefit utilities by operating on a fairly constant basis in both summer and winter. They also bring risk because their ability to get into production and stay there can be determined by fluctuating mineral prices. Future planning also needs to consider that mineral development customers, depending on the size of their electrical needs, may have demands for electricity that are beyond the ability of existing hydro infrastructure and even new medium to large infrastructure. This challenge and opportunity will be key to the Next Generation Hydro research and public conversations.

A substantial amount of work has been done over the years to identify and conceptualize possible hydroelectric projects in Yukon and nearby northern British Columbia. As mentioned, the Large Hydro Study and the 20-Year Resource Plan provide a complete overview. The 20-Year Resource Plan assessed hydroelectric sites that are near to the existing transmission grid or to possible future transmission lines and then sorted them by their LCOE[11] cost set at 2009 values (including the cost to connect to existing transmission system). Based on this assessment, they grouped different sets of projects by cost categories: less than 10 cents/kW.h, 10 – 15 cents/kW.h and those over 15 cents per kW.h (Appendix 2). This grouping could be structured differently if transmission costs were removed. This Work Plan will initiate such an analysis.

The Large Hydro Study assessed sites according to a variety of criteria that includes three broad categories: environmental aspects, social aspects, and financial aspects. The Large Hydro Study authors were tasked with identifying two sites in the 20-40 MW range, one in the 100 MW range and one in the 200 MW range (Appendix 2).

The Large Hydro Study initially reviewed a list of up to 175 hydro sites that had been previously identified in the Yukon, through numerous studies conducted since the 1960's with various levels of detail.

The Large Hydro Study consisted of 4 main steps:

1) Data Compilation: a total of 175 hydro sites were listed based on previously identified sites;

[11] Levelized Cost of Energy (LCOE) includes these assumptions for hydro: project life span is 67 years, 10% energy decrease for line loss, salvage cost of hydro and diesel projects is set to 0, the cost of diesel fuel to 80 cents/L and fuel efficiency 4 kWh/L and rate of return on the debt is set to 5.28% on the equity (Large Hydro Study assumptions page 15).

2) Pre-Screening: an exercise to remove sites based on engineering judgment and socio-economic/environmental criteria. A total of 58 hydro projects were retained;
3) Preferred sites: selected on the basis of defined objectives and promising development. A total of 25 hydro projects were retained;
4) Recommendations for further study: results of the study following site visit(s) and technical, economic, socio-economic and environmental qualitative assessment (selected criteria are discussed later). Four hydro projects were retained.

Many sites were rapidly discarded in the pre-screening phase based on the following rationale:

1) Scheme located on the main stem of the Yukon River (includes Teslin River);
2) Very distant from transmission lines or communities and projects (for example, northern Yukon);
3) Schemes that lie within a National Park or Territorial Park (Kluane National Park, Kusawa Lake, etc.);
4) Projects that flood a Yukon community;
5) Diversion project only with no power generation.

Further investigations and review of the previous studies allowed for narrowing down the list of potential hydro sites. A list of 25 preferred hydro sites were then retained for further analysis. Some 58 sites that were discarded or not selected could be considered in the Next Generation Hydro discussion, if brought forward by a First Nation. As part of this Work Plan, in the next year, a process will be put in place to re-assess at least the 25 past-preferred medium to large sites. The criteria of this Directive and Work Plan will be used to re-assess these and other key sites.

ACTIONS

The Next Generation Hydro and Transmission Viability Options Study will combine the information collected from the above-mentioned technical papers in a new analysis of the medium to large hydroelectric options. This analysis will include the Directive criteria and the need to address mid-term needs (supporting renewables), long-term needs and mitigate risks (scalability and transmission strategy). This examination will result in recommendations to the YDC board for consideration in the selection of the most appropriate Next Generation Hydro projects for business case development.

ENGAGEMENT PLAN

With the release of this Work Plan, YDC will begin the public conversation and engagement process that will form the basis of the Next Generation Hydro Discussion Paper. The engagement process will include a number of community visits and events where those that are interested can learn more about Yukon's energy challenges and how Next Generation Hydro will help meet our mid- to long-term needs. This conversation will be kept focused with the use of the Technical Papers and an associated speaker series. As well, there will be a conference that ties all the topics together.

CONTEXT

Yukon government has been part of several energy related planning processes over the last five years. In 2009, Yukon government consulted Yukoners on the Energy Strategy for the *Yukon and Climate Change Action Plan*. In 2010 and 2011, Yukon Energy led a public planning process to inform and update its 20-Year Energy Resource Plan. This included a number of workshops: on biomass (2011); waste to energy (2012); energy conservation (2012); liquefied natural gas (2012); and wind power (2013).

These events resulted in increased energy related dialogue, information sharing, and the recommendation of four key decision making criteria to be used when selecting energy options for the future (flexible, affordable, reliable and environmentally responsible). In general, the event participants discussed near-term options that the public owned utility – Yukon Energy – should be considering. Yukoners who participated expressed interest in being part of an ongoing conversation regarding clean energy options. They recognized that the cost of electricity is an important consideration and other values must also be considered. Moving forward, the following were suggested as the main options: energy conservation, hydro storage enhancements, wind, geothermal, and waste-to-energy electrical generation along with a recommendation to investigate biomass, solar and liquefied natural gas.

In 2011, Yukon Energy released its *20-Year Resource Plan* which addresses power generation and transmission options for the period of 2011 – 2030 and breaks these options out as: 1) resource options for implementation over the first five years (2011-

2015); and 2) planning activities for implementation to protect longer-term legacy resource development options for potential start of construction before or after 2021.

ACTIONS

First Nation Engagement

The Minister will contact each First Nation and CYFN leadership to introduce the Directive Work Plan. The YDC Chair will follow up with an offer to meet and discuss the Work Plan and how the First Nation would like to be engaged through the process. Where potential Next Generation Hydro exists, First Nations will be formally consulted and asked to work together with YDC via a protocol agreement[12].

Working agreements will be struck between affected First Nations and the Yukon government and YDC. First Nation Government officials will be instrumental in assisting YDC and researchers will be hired to begin the process of determining socio-economic impacts and benefits and environmental values related to potential qualified Next Generation Hydro project options.

Public and Stakeholder Engagement

Community meetings will be held to set the stage for the Next Generation Hydro discussions to occur in the next year. At these meetings, the Hydroelectric Power Planning Directive and the activities of this Work Plan will be explained. In each community, students will be invited to learn more about Yukon's energy future and the role hydroelectricity can play.

Stakeholder groups will be contacted and interviewed. If there is interest, the YDC's chair and or Project Coordinator can present to the board and or membership an introduction to the Work Plan process.

[12] Yukon Energy has a number of existing protocol agreements with Yukon First Nations.

Events:

Technical Paper Discussions

As the technical papers are produced, they will be made available to Yukoners for discussion (examples include on-line dialogue, a summary household flyer or a videotaped speaking event). Technical working sessions related to each paper may also be held.

Yukon First Nation Energy Forum Part 2

As a follow-up to the first Yukon First Nation Energy Forum, the second Forum will introduce the energy context, outline the potential for medium to large hydroelectric projects and other renewables, discuss transmission strategy, investment models and opportunities and how impacts to values might be addressed. A technical paper may be produced from this Forum.

Next Generation Hydro Conference

A two-day public event or conference will be held in early 2015 to present and discuss all the information collected in the technical papers and the Next Generation Hydro and Transmission Viability Options Study. A key element of these discussions will be how large hydro fits mid- to long-term future growth scenarios. How will Next Generation Hydro and supportive renewable energy projects match these scenarios? How will risks be mitigated with transmission strategies and through the selection of scalable projects?

Next Generation Hydro Business Case Announcement

Once the YDC Board has decided which medium to large hydroelectric project to recommend as “potential” future Next Generation Hydro, an announcement will be made. Upon approval to proceed, the YDC Board and Project Coordinator will seek to have the business case for Next Generation Hydro completed. The business case will act as a prospectus for future investment to be acquired by the Yukon government from First Nations Governments, the Government of Canada, other governments, the private sector and from funding programs. The Business Case will include the Next Generation Hydro cost per stage of work. It is important to note that the Work Plan is an important first step towards a future project. There are many steps after that first one. A plan could be years in the making. Both project assessment and regulatory licensing need to take place before a final decision to build or construct Next Generation Hydro can be made.

DELIVERABLES, BUDGET, TIMELINES AND ORGANIZATIONAL STRUCTURE

The Yukon government has set aside $2 million in the 2014/2015 Budget (to be approved) for the implementation of the Hydroelectric Power Planning Directive Work Plan. The following section outlines the key activities, deliverables and timelines associated with Work Plan implementation.

DELIVERABLES

A series of technical papers will be released to guide the Work Plan engagement process. These technical papers will be shared with First Nation Governments, agencies, stakeholder groups, and the public.

Technical Paper – Economic Growth Scenarios and Energy Demand Forecasts
This paper will update mid- and long-term scenarios using a variety of different assumptions that take into account GHG targets and other related policy considerations. Different economic scenarios will be developed and for each, an energy demand forecast will be constructed. This work will present Yukoners with scenarios mid (10 to 20 years) to long-term (20 to 50 years) so discussions can be framed in consideration of future generations.

Technical Paper – Scalability of Next Generation Hydro Project Options

This paper will address Next Generation Hydro Project risks by looking at the pros and cons of various hydro projects, in terms of their flexibility to be scalable (build-outs and fit to supporting renewables) and their relative ability to respond to demand forecasts and growth scenarios in the mid- to long-term.

Technical Paper – Jurisdictional Transmission Line Technical Logistics Analysis
This paper will address Next Generation Hydro project risks by asking the question whether strategic investments to extend Yukon's transmission system to another jurisdiction would make a difference to: 1) the selection of Next Generation Hydro options; and 2) the ability to scale out energy supply and mitigate industrial load interruption risks. As well, what amount and what location of Yukon based load and supply is required to make a transmission line connection technically feasible?

Technical Paper – Jurisdictional Transmission Connection Market Assessment This paper will address the business case of jurisdictional connection. What are the market economics associated with a jurisdictional transmission connection (Alaska and BC)? Would other jurisdictions sell power to the Yukon? Would other jurisdictions consider Yukon power affordable and would they be interested in buying it? If jurisdictional transmission was to be considered viable, how should it be built out and what Next Generation Hydro options would best suit this build-out?

Technical Paper – Project Cost per Hydro Development Phase

This technical paper will address the Next Generation Hydro Project's upfront capital project needs and risks, per stage of development. Project costs can be split include various phases including conceptual design, prefeasibility, feasibility, planning, construction and operations. Financial risk mitigation will be discussed in terms of types of available funding models and the sources of funding and partnership opportunities that exist.

Technical Paper – Positive and Negative Socio-economic and Environmental Effects of the Project

This technical paper will address the possible positive and negative socio-economic and environmental effects of a medium to large hydro project and related infrastructure. Specifically, it will address best practices for maximizing benefits, minimizing adverse effects and mitigating any unavoidable negative impacts. As well, this technical paper will address best practices regarding effects that might have particular impacts on and opportunities for, the First Nation or First Nations in whose traditional territory the project may be located. Important values that will be affected by a hydro project will be noted and discussed with YESAB so that a comprehensive and pro-active approach can be taken to assessment of some potential future project.

Next Generation Hydro and Transmission Viability Options Study will combine the information collected from the above-mentioned technical papers in a new analysis of the medium to large hydroelectric options. This analysis will include the Directive criteria and the need to address mid-term needs (supportive renewables), long- term needs and risk mitigation (scalability and transmission strategy). This final document will be given to the YDC board to inform the decision on the most appropriate Next Generation Hydro Projects for business case development.

Next Generation Hydro Discussion Paper – This summarizes the engagement process, which will include community meetings, stakeholder meetings, and conference.

Yukon First Nation Energy Forum 2 will be held to help inform First Nations leadership, technicians and government officials. This Forum will build from the first Yukon First Nation Energy Forum. It will introduce the energy context, outline the potential for medium to large hydroelectric power and other renewables, discuss transmission strategy, investment models and opportunities and how impacts to values could be addressed. A technical paper may be produced from this Forum.

Next Generation Hydro Business Case will act as a business prospectus or business rationale for future investment to proceed with Next Generation Hydro development. Investment will be sought from Yukon government, First Nations Governments, the Government of Canada, other governments, the private sector and from funding programs. The Business Case will include the cost per stage of work for a Next Generation Hydro project, which may be a 10 to 15 year process.

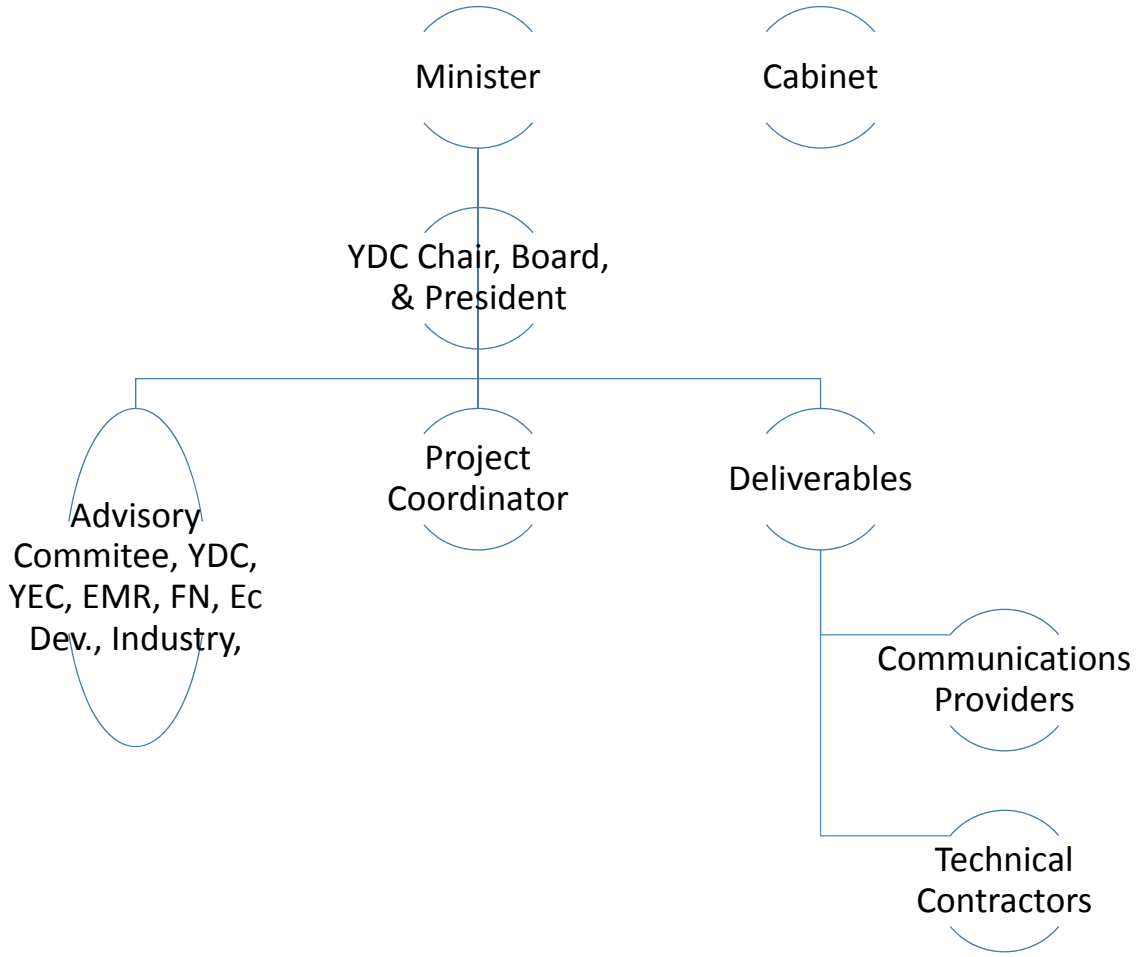
WORK PLAN FINANCIAL AND HUMAN RESOURCES

Next Generation Hydro Project Coordinator **Advisory Committee** **Technical Advisory Committee** **Board Engagement & Travel Expenses** • Reports the Chair of YDC and the Board • Liaisons with the Advisory Committee (optional) • Coordinates contractors and project deliverables • Writes summary Next Generation Hydro Discussion Paper • No office cost included	$350,000
Technical Work Contract(s) • Next Generation Hydro and Transmission Viability Options Study • Technical Papers • Prefeasibility and values research • Next Generation Hydro site visits (some field work required) • Next Generation Hydro Business Case development	.9 to 1.150 million
Engagement Process - Community meetings - Stakeholder meetings - Education materials - First Nation Energy Forum 2 - Technical speaker series and video coverage - Energy / Next Generation Hydro and Transmission Viability Conference	$500,000 +

Advisory Committee

YDC may establish an Advisory Committee to inform the work to be carried out in the next year. To best reflect and advise on the future energy needs of the Yukon, the Directive Advisory Committee may include a mix of governmental and nongovernmental interests. The Advisory Committee would then make recommendations to the YDC Board of Directors.

NEXT GENERATION HYDRO ORGANIZATION CHART



SCHEDULE OF PLANNING STAGES

This planning schedule is for the work to be accomplished in the next year to fulfill the Hydroelectric Power Planning Directive. This year represents the first of what may be a 10- to 15-year process to build a Next Generation Hydro Project in the Yukon.

Month	Year 1 Next Generation Hydro Project Tasks
May	Hire Work Plan project coordinator and related resources.
May	Minister contacts/meets First Nation leaders and CYFN leadership.
June	Chair of YDC meets with key stakeholders and First Nation Development Corporations.
June	Chair of YDC and Project Coordinator meets with Chair of YESAB, Water Board and other agencies to explain project.
June	YDC issues 3 RFPs for contract work: 1. Contracted Project Coordinator 2. Next Generation & Transmission Viability Options Study Contract a. Technical papers b. Business Case 3. Communications Support Activities Contract
June	Project definition workshop with Contract Team to define the scope and amount of work that can be done for each of the Technical Papers and other deliverables.
June / July	Development and release of engagement support (education and visioning materials).
June / July	YDC Chair leads dialogue with First Nations.

Month	Year 1 Next Generation Hydro Project Tasks
June / July	Begin preliminary value discussions as part of the socio-economic assessment.
June / July	Yukon Government officials contact Government of Canada officials.
September - November	Community meetings Technical paper speakers series
November	First Nation Energy Forum Part 2
February / March	Next Generation Hydro Energy Conference
March	Summarize work done to date and information from engagement process in **Next Generation Hydro Discussion Paper.**
April	YDC Board makes hydro project selection decision, from which the Next Generation Business Case is written.

REFERENCES:

Annual Report 2012 Yukon Minerals Advisory Board (www.emr.yk.ca/mining/pdf/ymab_annual_report_2012.pdf)

Yukon Energy 20-Year Resource Plan: 2011- 2030. December 2011.

Yukon Energy Corporation 2009 Large Hydro Stage 1: initial Evaluation. Prepared by Aecom. November 2010.

Yukon Government. 2014. Yukon Economic Outlook. Department of Economic Development. http://economics.gov.yk.ca/

APPENDIX 1 – SOCIO-ECONOMIC AND ENVIRONMENTAL CONSIDERATIONS

Socio-economic and environmental considerations will play a key role in development of any future hydroelectric project. The following tables summarize potential socio-economic valued components and potential effects, the environmental components within the study area and other project authorizations likely required for the Next Generation Hydro project.

Table 1. Potential socio-economic valued components and potential effects.

Valued Components	Potential Effects
Land and Resource Use	
First Nation Category A/B Settlement Land (or Interim Protected Land in the traditional territories of First Nations with no Final Agreement in place) First Nation traditional/cultural pursuits, including Traditional Knowledge – hunting, fishing and gathering Land tenure, including shoreline structures Hunting and Fishing/ Eco-tourism Outfitting Trapping Recreation Tourism Placer and Quartz Exploration/Mining Land Use Plans	• Removal of land/resources from use through inundation, development (clearing, installation of infrastructure), noise/visual disturbance, or through impacts on water flow/quality and wildlife/fish populations. • Impedance of access to land/resources. • Aesthetic impacts. • Non-conformance with local or regional Land Use Plans.
Economic Resources	
Local/Territorial Employment Opportunities Local/Territorial Goods and Services Procurement Economic Opportunities for First Nations Traditional Economy Project Costing And Financing Project Sustainability	• Significant economic inputs to local and regional economies, including employment opportunities. • Boom-and-bust economic impacts on affected communities, associated with the end of the construction phase.
Heritage Resources	
Historic/ archaeological sites or objects, including traditional burial grounds	• Impacts on heritage resources through inundation and/or development (clearing, installation of infrastructure).
Community Structure and Dynamics	
Health Status Community Well-Being and Vitality Cultural Well-Being Community Stability Community/Local Services and Infrastructure Education and Training	Potential effects on Community Structure and Dynamics are associated primarily with the construction phase. • Changes to family structure • Increased draw on community services and infrastructure • Crime rate fluctuations • Changes to community cohesion • Changes to patterns of traditional land and resource use • Individual capacity building through training and work experience

Table 2. The environmental components within the study area that will need to be described

Environmental Components	Detail	Valued Component*
Atmospheric Environment		
Atmospheric Environment	• Climate and meteorology • Ambient air quality • Ambient Noise level	Greenhouse Gases; Human Health
Aquatic Environment		
Hydrology	Description of all lakes, streams, rivers within study area, watershed boundaries, river hydraulics/hydrology, bathymetry, Ordinary High Water Mark (OHWM), flood zones, ice formation, dynamics and melt patterns;	Fish and Fish Habitat; Human Health; Navigation
Geomorphology	Erosion, sedimentation, channel dynamics and sediment supply and quality	Fish and fish habitat; Vegetation and Ecological Communities; Wildlife Resources; Human Health
Water quality and quantity	Surface and groundwater sources	Fish and fish Habitat; Human Health
Delineation and Description of riparian habitat	Shoreline, flood zones, back channels, wetlands	Ecological Communities
Vegetation	Aquatic and Riparian	Ecological Communities
Aquatic Fauna	Composition, abundance, distribution, population dynamics and habitat utilization	Fish and Fish Habitat
Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.	Ecological Communities
Terrestrial Environment		
Land Features	• Geology (bedrock and surficial) • Geo-chemical characterization of rock types, sediments that may be disturbed • Terrain and Soil • Seismicity • Mercury levels in proposed inundated areas • Identification and characterization of erosional areas or areas subject to instability, slumping or Landslides • Groundwater movement, aquifer recharge zones • Permafrost conditions	Forestry; Vegetation and Ecological Communities; Fish and Fish Habitat; Wildlife Resources; Greenhouse Gases
Fauna	Composition, abundance and distribution, population dynamics and habitat utilization	Wildlife Resources
Flora	Composition, abundance and distribution, forest inventory, ecological land classification. Special consideration for medicinal herbs, berries harvested by First Nation communities.	Ecological Communities; Vegetation
Wetlands	Delineation, characterization and classification	Ecological Communities
Mercury	Concentrations, mobility and fate within the riparian ecosystem	Human Health
Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.	Ecological Communities
Human-Wildlife Interaction		Wildlife Resources; Human Health

*Additional Valued Components will be identified as project and Baseline collection programs advance.

Table 3. Other project authorization examples.

Authorization	Activity	Enacting Legislation	Regulatory Agency
Land Tenure/ Land Use			
Application for Land	Tenure for land lease.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Land Use Permit	Temporarily using or occupying Commissioner's Land.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Quarry Permit, Quarry Lease Air Emissions Permit (if excavation is greater than 4 ha)	Obtaining gravel/sand from a quarry.	*Territorial Lands Act, Lands Act*, Land Use Regulation *Environment Act,* Air Emissions Regulation	Energy, Mines & Resources, Lands Branch Environment Yukon, Environmental Programs
Land Use Permit, Disposition Approval	Clearing or installing a utility right-of-way.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Access Permit	Constructing road access on highway right-of-way.	*Highways Act*, Highways Regulation	Highways & Public Works, Transportation Maintenance Branch
Land Use Permit Permit under *Highways Act* Section 7(2)	Construction of new road access.	*Territorial Lands Act, Lands Act*, Land Use Regulation *Highways Act*, Highways Regulation	Energy, Mines & Resources, Lands Branch Highways & Public Works, Transportation Maintenance Branch
Licence of Occupation	Use of land within highway right-of-way.	*Highways Act*	Highways & Public Works, Transportation Maintenance Branch
Work in Right-of-Way Permit	Perform work within highway right-of-way.	*Highways Act*, Highways Regulation	Highways & Public Works, Transportation Maintenance Branch
Sign Permit	Erect sign within highway right-of-way.	*Highways Act*, Highways Regulation	Highways & Public Works, Transportation Maintenance Branch
Burning Permit	Burning refuse wood.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Forest Resources Permit	Clearing of forest resources incidental	*Forest Resources Act*	Energy, Mines & Resources, Forest

Authorization	Activity	Enacting Legislation	Regulatory Agency
	to other activity (including land use, road construction, working within a Right-of-Way, etc.)		Management Branch
Conformance to Regulation	Inadvertent destruction of nests and eggs due to forest clearing. is called "incidental take"	*Migratory Birds Convention Act,* Migratory Birds Regulations	Environment Canada
Construction/Building-Related			
International River Permit	Improvement project (including hydroelectric dams) on international rivers.	*International Boundary Waters Treaty Act*, International River Improvements Regulation	Environment Canada, Environmental Protection
Building Permit	Construction of buildings outside a municipality. Installation of fuel storage tanks.	*Building Standards Act*	Community Services, Building Safety
Plumbing Permit	Plumbing outside of Whitehorse	*Building Standards Act*	Community Services, Building Safety
Permit to Install a Sewage Disposal System	Onsite sewage disposal system.	*Public Health & Safety Act,* Sewage Disposal Systems Regulation	Health & Social Services, Environmental Health Services
Electric Permit	Electrical work.	*Electrical Protection Act,* Canadian Electrical Code	Community Services, Building Safety
Gas Installation Permit	Gas installation or modification.	*Gas Burning Devices Act*	Community Services, Building Safety
Registration	Installation of power boilers over 10 kW, hearing boilers over 20 kW, pressure vessels and piping systems.	*Yukon Boiler and Pressure Vessel Act*	Community Services, Building Safety
Air Emissions Permit	Operation of fuel burning equipment greater than 5Mbtu/hr.	*Environment Act,* Air Emissions Regulation	Environment Yukon, Environmental Programs
Land Use Permit Water Licence	Bridge crossing (if bridge crosses navigable water)	*Territorial Lands Act, Lands Act*, Land Use Regulation *Waters Act*	Energy, Mines & Resources, Lands Branch Water Board

Authorization	Activity	Enacting Legislation	Regulatory Agency
Contaminants and Waste			
Solid Waste or Waste Management Permit Land Lease	Solid waste disposal facility or commercial dump.	*Yukon Environment Act*, Solid Waste Regulations	Environment Yukon, Environmental Programs
Storage Tank Systems Permit Land Use Permit	Storage and handling of petroleum products.	*Yukon Environment Act*, Storage Tank Regulation *Territorial Lands Act, Lands Act*, Land Use Regulation	Environment Yukon, Environmental Programs
Application for Operation, Closure, Abandonment, or Renovations to Storage Tanks	Use of storage tanks.	*Environment Act*, Storage Tank Regulation	YG Community Services, Protective Services Branch, Fire Marshall's Office
Land Use Permit	Fuel caches or more than 4000 L or any single container of more than 2000 L on Commissioner's Land.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Special Waste Permit	Handling, disposal, generation or storage of special (hazardous) wastes.	*Environment Act*, Special Waste Regulation	Environment Yukon, Environmental Programs
Air Emissions Permit	Release of air pollutants (e.g. incinerator, diesel generators).	*Environment Act,* Air Emissions Regulation	Environment Yukon, Environmental Programs
Air Emissions Permit/ Waste Management Permit	Operation of solid waste incinerator	*Environment Act,* Air Emissions Regulation	Environment Yukon, Environmental Programs
Explosives			
Land Use Permit	Use of more than 50 kg of explosives on Commissioner's land in any 30-day period.	*Territorial Lands Act, Lands Act*, Land Use Regulation	Energy, Mines & Resources, Lands Branch
Permit for Use of Explosives	Overnight storage of explosives at any site other than a mine or quarry.	*Explosives Act*	Natural Resources Canada, Minerals & Metals Sector

Authorization	Activity	Enacting Legislation	Regulatory Agency
Explosives Magazine Permit	Explosives storage.	*Explosives Act*	Yukon Worker's Compensation Health and Safety Board, Occupational Health & Safety
Underground and Surface Authorization to Conduct Blasting in Yukon	Blasting.	Occupational Health and Safety Regulations, Part 14: Blasting Regulations	Yukon Worker's Compensation Health and Safety Board, Occupational Health & Safety
Temporary Blaster's Permit	Temporary blasting.	Occupational Health and Safety Regulations, Part 14: Blasting Regulations	Yukon Worker's Compensation Health and Safety Board, Occupational Health & Safety
ANFO Permit	Manufacture of ANFO.	*Explosives Act*	Natural Resources Canada, Minerals & Metals Sector
Factory Licence	Manufacture of explosives other than ANFO.	*Explosives Act*	Natural Resources Canada, Minerals & Metals Sector
Transportation			
Over-dimensional or Over-weight Vehicle Permits	Oversize trucking.	*Highways Act*	YG Highways & Public Works, Transportation Services Branch
Certificate and/or Permit for Transport of Dangerous Goods Special Waste Permit and Waste Manifest	Transport of dangerous goods/waste.	*Transportation of Dangerous Goods Act* *Environment Act*, Special Waste Regulation	YG Highways & Public Works, Transportation Services Branch Environment Yukon, Environmental Programs

Table 5. The environmental components that will need to be described for a future Next Generation Hydro project.

Environmental Components	Detail	Valued Component*
Atmospheric Environment		
Atmospheric Environment	• Climate and meteorology • Ambient air quality • Ambient Noise level	Greenhouse Gases; Human Health
Aquatic Environment		
Hydrology	Description of all lakes, streams, rivers within study area, watershed boundaries, river hydraulics/hydrology, bathymetry, Ordinary High Water Mark (OHWM), flood zones, ice formation, dynamics and melt patterns;	Fish and Fish Habitat; Human Health; Navigation
Geomorphology	Erosion, sedimentation, channel dynamics and sediment supply and quality	Fish and fish habitat; Vegetation and Ecological Communities; Wildlife Resources; Human Health
Water quality and quantity	Surface and groundwater sources	Fish and fish Habitat; Human Health
Delineation and Description of riparian habitat	Shoreline, flood zones, back channels, wetlands	Ecological Communities
Vegetation	Aquatic and Riparian	Ecological Communities
Aquatic Fauna	Composition, abundance, distribution, population dynamics and habitat utilization	Fish and Fish Habitat
Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.	Ecological Communities
Terrestrial Environment		
Land Features	• Geology (bedrock and surficial) • Geo-chemical characterization of rock types, sediments that may be disturbed • Terrain and Soil • Seismicity • Mercury levels in proposed inundated areas • Identification and characterization of erosional areas or areas subject to instability, slumping or Landslides • Groundwater movement, aquifer recharge zones • Permafrost conditions	Forestry; Vegetation and Ecological Communities; Fish and Fish Habitat; Wildlife Resources; Greenhouse Gases
Fauna	Composition, abundance and distribution, population dynamics and habitat utilization	Wildlife Resources
Flora	Composition, abundance and distribution, forest inventory, ecological land classification. Special consideration for medicinal herbs, berries harvested by First Nation communities.	Ecological Communities; Vegetation
Wetlands	Delineation, characterization and classification	Ecological Communities
Mercury	Concentrations, mobility and fate within the riparian ecosystem	Human Health
Species of special interest (flora and fauna)	Rare, vulnerable or endangered with consideration for any listed within the Endangered species act or species at risk act.	Ecological Communities
Human-Wildlife Interaction		Wildlife Resources; Human Health

*Additional Valued Components will be identified as project and Baseline collection programs advance.

APPENDIX 2 – SUMMARY OF 20-YEAR RESOURCE PLAN AND LARGE HYDRO STUDY

The following is a quick overview of the findings related to medium and large hydro project options discussed in the two key documents referred to in this Work Plan. The Yukon Energy 20-Year Resource Plan and the 2009 Large Hydro Stage 1: Initial Evaluation.

Yukon Energy 20-Year Resource Plan Summary

The Resource Plan breaks longer-term hydro resource options out into the following categories:

Hydro Options at less than 10 cents/kW.h – Nine sites were/are identified based estimated Full Utilization LCOE's (2009$) below 10 cents per kW.h/year that could contribute 4,390 GWh per year of average annual sustainable energy (net of duplication among sites); four of these sites are Medium scale (11-60 MW) that could together provide over 850 GWh per year and the other sites are Large scale (>60 MW).

Medium Hydro Projects (<60 MW) under 10 cents/kW.h

- Hoole Canyon with storage (40.4 MW / 275 GWh)
- Granite Canyon small (60 MW / 400 GWh)
- Slate Rapids (41.6 MW / 266 GWh)
- Finlayson (17.0 MW / 128.9 GWh)

Large Hydro Projects under 10 cents/kW.h

- Granite Canyon High (254 MW / 1,783 GWh)
- Fraser Falls Low (100 MW / 700 GWh)
- Granite Canyon Low (80 MW / 600 GWh)
- Fraser Falls High (300 MW / 2,100 GWh)
- Combined Slate Rapids & Hoole (69.4 MW / 659 GWh)

Hydro Options at 10 – 15 cents/kW.h – Eight sites were identified with Full Utilization LCOE's between 10 and 15 cents per kW.h and over 2,000 GWh of additional average annual sustainable energy; five of these sites are Medium scale (over 850 GWh/year); the other sites are Large scale (>60 MW).

- Ross Canyon with storage (30 MW / 181 GWh)
- False Canyon (58 MW / 370 GWh)
- Two Mile Canyon (53.1 MW / 280 GWh)
- Combined Slate Rapids & Hoole (50.1 MW / 351.1 GWh)
- Slate Rapids (powerhouse at foot of dam) (22.3 MW / 156.3 GWh)
- Detour Canyon (65 MW / 435 GWh)
- Detour Canyon w storage at Pelly Lake (100 MW / 585 GWh)
- Liard Canyon (93.5 MW / 659 GWh)

The following are over 15 cents (Levelized Cost = c/kWh) but could be less if new jurisdictional transmission existed.

If southeast Yukon transmission line were built these costs would be lower:

- Moon Lake (5.8 MW / 32.9 GWh)
- Tutshi River (4.2 MW / 30.3 GWh)
- Tutshi (Windy Arm) (5.9 MW / 39.4 GWh)

If a transmission line were built to Watson Lake from Faro these project costs would be lower:

- Middle Canyon (38 MW / 200 GWh)
- Upper Canyon (25.2 MW / 176.6 GWh)

Other Medium Scale Hydro Options – a further two Medium scale sites located north of the Watson Lake are identified with Full Utilization LCOE's under 15 cents per kW.h if exceptionally high transmission cost estimates to connect to the existing grid are excluded from consideration. Together, these sites could provide over 375 GWh per year of additional average energy.

Large Hydro Study Summary

Evaluation criteria

The selected preferred hydro sites were studied in more depth in the Large Hydro Study. This included review of previous information; site visits for the most promising hydro sites and a desktop comparison analysis of the main project aspects.

As a fundamental guideline, three key aspects have to be met for a promising and ultimately successful hydro project,

1) Technical and financial feasibility
2) Socio-economic endorsement
3) Environmental suitability.

The most economical project may not be the optimal project to develop if it doesn't succeed in one of the two other categories.

The Large Hydro Study has evaluated all of the retained 25 preferred sites based on the three categories. Evaluation criteria were selected for each category. Attributes (better-worse, none-moderate-significant, etc.) were given to each criteria with a point system to equally classify all sites. The importance of each evaluation criteria was determined prior to the assessment. Ultimately, the recommended sites for further study were the ones that scored the best over the three categories summed together.

Some of the retained criteria included:

1) Technical and economic feasibility

- Capital cost
- Cost of Energy
- Opportunity for stage development
- Installed capacity
- Firm winter power
- Average annual energy
- Distance and size of transmission line required
- Technical complexity

2) Socio-economic endorsement

- Interprovincial/international water implications
- Protected hydro project area
- Extent of impact to existing land disposition
- Effects on harvesting
- Potential impact to settlement land
- Heritage resources in project footprint

- Recreational/tourism value

3) Environmental suitability

- Salmon present in river
- Project footprint (including inundation)
- Protected environment area
- Access to previously inaccessible wilderness
- Permafrost challenges within project footprint
- Greenhouse gas reduction
- Other issues

Each of the 25 preferred hydro schemes were carefully reviewed for their technical feasibility, based on previous engineering studies and/or available information (topographical maps, hydrological data, etc.). Site visits were conducted at 10 sites to collect additional information and to review and update the proposed project layout (if available) for the most promising sites. Previous cost estimates were reviewed, updated when required, and inflated to 2009 dollar value. Reservoir mapping of the preferred sites where flooding is to be expected was done.

Preferred Hydro Sites

A summary of the selected preferred hydro sites in the Large Hydro Study are presented. Key parameters relevant to each site are also presented in the tables for comparison purposes. The level of detail of existing reference studies is also presented, and are referred to as:

- Desktop study: only simple office calculations and layout determination completed based on existing topographical maps (1:50,000)
- Reconnaissance study: study that involved first a site visit to observe the site main components, and then office calculations and layout determination based on existing topographical maps and observations from the site visit
- Pre-feasibility study: detailed conceptual engineering study to determine a viable layout and long term power benefit based on a real operation scheme. The study is based on various source of information such as a detailed site visit with a team of expert, preliminary topographical survey, geophysical and geotechnical investigations on site.

In the last assessment round of the Large Hydro Study, 3 of the 25 sites were recommended for further study based on the study criteria parameters (2 in 20-40 MW, 1 in the 100 MW, and 1 in the 200 MW) and are highlighted in blue in Tables 3-2 and 3-3 (various development schemes for each of them). A short description of each of them is presented below.

1) **Granite Canyon (Pelly River upstream of Pelly Crossing)**

   Based on the results of the initial evaluation, it is considered to be the best site in the Yukon for hydropower production both from a technical and sustainability perspective. This site could be staged up to accommodate load forecast. Development in the 60 to 250 MW range was proven to be economical, in part due to favorable geologic conditions and being located close to an existing 138 kV transmission line.

   This site will however require the creation of a large reservoir, partially located on the First Nation Settlement Land. It is also located on a salmon producing river.

   A complete pre-feasibility with on-site geotechnical investigations was completed for this site in 1982. It can serve as the basis for further studies. Prefeasibility updates are recommended.

2) **Hoole Canyon and Slate Rapids (Upper Pelly River east of Ross River)**

   The development of these two sites appears to be the most economic medium-sized hydro development in the Yukon, with an installed capacity in the 30 to 70 MW range. Various schemes could be developed, but would all require storage in upstream lakes (Fortin Lake or Pelly Lakes).

   This site is one of the best sites for social and environmental aspects. Some concerns related to the salmon population on the Pelly River and the need to manage existing lakes (impact on fish population). The site is also located in an area that is currently inaccessible.

A complete pre-feasibility study was completed for Hoole Canyon site in 1983. Slate Rapids has however only been the subject of reconnaissance type studies and would require additional work to firm up a viable layout. It will serve as the basis for further studies. (Prefeasibility update recommended.)

3) **Finlayson River**

The Finlayson River site was selected as the most attractive hydro project in the less than 60 MW class. It has the advantage of having a natural high head in comparison with most other sites in the Yukon. Storage would be obtained by regulating Finlayson Lake. The major downside of this site is the need for a 230 km long transmission line to connect to Faro.

Only a desktop study was completed in 1991 for this site. In order to increase the level of detail of this site equivalent to the one of Hoole Canyon or Granite Canyon, further studies are required. A pre-feasibility study with detailed topographical information and geological conditions would need to be performed.

Some of the 25 preferred sites that did not reach final recommendation in the Large Hydro Study may still have attractive attributes on some or all of the three key project aspects (technical/financial, socio-economic, environmental) and could be reviewed as part of the Next Generation Hydro Project. These sites include:

- Fraser Falls (Stewart River, east of Mayo)
- Two mile canyon (Hess River, east of Mayo)
- Detour Canyon (Pelly River, 100 km east of Pelly Crossing)
- Frances River – 3 Canyons (north of Watson Lake, up to Frances Lake)
- Liard Canyon (Liard River 5 km east of Watson Lake at Yukon/BC border)
- Ross Canyon (Ross River, north of Ross River)

A list of some of those previously identified sites are presented in Table 3. This list includes additional sites that were not retained in the list of preferred sites in the Large Hydro Study.

Table 1 Large Hydro Study Preferred Medium Hydro Projects (<60 MW)

River	Site Name	Location	First Nation Traditional Territory	Installed capacity (MW)	Annual Energy (GWh)	Distance to WAF Grid – 138 kV line (km)	Estimated construction cost (M$ 2009)*	Levelized Cost of Energy ($/kWh)*	Year of last study	State of study
Pelly River	Granite Canyon (small)	East of Pelly Crossing	Selkirk	60	360	25	645	0.083	1982	Pre-feasibility
	Hoole Canyon	East of Ross River	Kaska	13-40	60-248	100	265-415	0.078-0.204	1983	Pre-feasibility + geotechnical investigations
	Slate Rapids	East of Ross River	Kaska	22-42	141-239	140	385-430	0.084-0.127	1983 (modified 2009)	Reconnaissance
Finlayson River	Finlayson	East of Ross River	Kaska	17	116	230	150	0.06	1991	Desktop
Frances River	Upper Canyon	North of Watson Lake	Liard	25	159	310	310	0.09	1977	Pre-feasibility
	False Canyon	North of Watson Lake	Liard	58	333	335	640	0.089	1982	Pre-feasibility
	Middle Canyon	North of Watson Lake	Liard	38	180	360	350	0.09	1982	Reconnaissance
Ross River	Ross Canyon	North of Ross River	Kaska	30	163	60	460	0.131	1982	Pre-feasibility
Hess River	Two-Mile Canyon	East of Mayo	Nacho Nyak Dun	53	252	100	635	0.117	1968	Desktop
Primrose River	Upper/Lower Primrose	West of Whitehorse	Champagne Aishihik	16	83	90	340	0.191	2007	Reconnaissance

*Construction costs and levelized cost of energy are presented without the cost of the transmission line

Table 2 Large Hydro Study Preferred Large Hydro Projects (>60 MW)

River	Site Name	Location	First Nation Traditional Territory	Installed capacity (MW)	Annual Energy (GWh)	Distance to WAF Grid (km)	Estimated construction cost (M$ 2009)*	Levelized Cost of Energy ($/kWh)*	Year of last study	State of study
Pelly River	Granite Canyon (low)	East of Pelly Crossing	Selkirk	80	594	25	905	0.071	1982	Pre-feasibility
	Granite Canyon (high)	East of Pelly Crossing	Selkirk	254	1605	25	1,630	0.047	1982	Pre-feasibility
	Detour Canyon	East of Pelly Crossing	Selkirk	65-100	392-527	100	1,000-1,240	0.11-0.119	1975	Reconnaissance
	Hoole Canyon and Slate rapids combined	East of Ross River	Kaska	50-69	316-413	140	655-710	0.08-0.096	1983 (modified 2009)	Reconnaissance (pre-feasibility for Hoole)
Liard River	Liard Canyon	In Watson Lake	Liard	94	593	445	1,035	0.081	1975	Reconnaissance
Stewart River	Fraser Falls (low)	East of Mayo	Nacho Nyak Dun	100	630	45	1,305	0.096	1975	Reconnaissance
	Fraser Falls (high)	East of Mayo	Nacho Nyak Dun	300	1890	45	2,480	0.061	1975	Reconnaissance

*Construction costs and levelized cost of energy are represented without the cost of the transmission line

APPENDIX 3 – HYDROELECTRIC DEVELOPMENT STAGES

Many hydro sites in the Yukon have been the subject of engineering studies with various level of detail, ranging from desktop only studies to complete pre-feasibility supported by a field investigation program.

An overview of the level of detail of each stage of engineering studies related to the development of a hydroelectric project is presented below. An overview of the associated environmental studies and permitting process for each step is also included.

1) ***Desktop study***

   Simple office calculations and layout determination completed based on existing topographical maps (1:50,000), available flow data (from Water Survey of Canada gauging stations, from the same river if possible, or nearby rivers otherwise), and available geological maps. No site visit is conducted. A site layout drawing may or may not be produced.

2) ***Reconnaissance/Conceptual engineering study***

   Study that involved first a reconnaissance site visit to observe the site main components, including river layout and abutments, geological features, and may include simple measurements (head drop). Complemented with simple office calculations to determine power benefits. A project layout is proposed based on existing topographical maps and observations from the site visit. A site layout drawing will be produced. An order-of-magnitude cost estimate (+-50-100%) is produced. A scoping level of assessment and regulatory approvals is usually completed to identify the main development issues, and provide recommendations.

3) ***Pre-feasibility engineering study***

   Detailed conceptual engineering study determines the viable layout and long-term power benefit based on a realistic operation scheme. Preliminary engineering is based on site mapping and site hydrology. The study is initiated by

a detailed site visit with a team of expert including a geologist and hydro technical engineer. For larger project, a preliminary field investigation program will be completed, including preliminary topographical survey and geophysical investigations on site. The investigation program will only include a few boreholes at key locations (i.e. dam site) and seismic lines for example. Planning of detailed geotechnical investigations for the feasibility study is usually conducted. A set of design criteria is established for the project, including a hydrological study. Preliminary design of main works is conducted to define key dimensions. A set of drawing is produced to cover all main works of the project. A ***cost*** estimate based on a bill of quantities is prepared at a +-30 to 50% is produced.

The site visit will usually also involve an environmental specialist. The environmental and socio-economic components for the effects assessment are defined. Baseline study may be conducted at the same time. Consultation and preliminary agreements with First Nation and other governments are usually put in place. Approvals and permits for geotechnical site investigations for feasibility study are obtained.

4) Feasibility engineering study

The study is initiated by a complete intrusive geotechnical investigations program and detailed topographic survey. It is conducted for the main works for the project, but also potential construction material sources, access roads and transmission lines. The engineering level of detail is upgraded based on the results of the investigation program. The design criteria are updated and expanded if necessary. Alternative layouts are considered and project optimization is conducted, which can include cost comparison analysis. Works are designed in more details and all components are now assessed. Continuous flow monitoring should continue and will allow updating power estimates. The operation scheme will be optimized. Detail hydraulic studies (computer or scale modelling) will be conducted to optimize the main works and minimize construction costs. At the end of the study, the proposed layout, design basis and criteria will all be freeze to continue with detailed engineering phase. Detail project planning is conducted to determine viable construction methods and the

associated optimal schedule. A detail set of drawing is produced; including is work and associated components, and construction layout. A cost estimate at a +-15-20% level is prepared.

The environmental effects assessment is conducted at the same time as the pre-feasibility study (may have started before). The environmental effects assessment review process is launched in parallel of the study with a project application to YESAB. Final agreements with First Nation and Governments are established.

A formal decision to proceed with the project to construction is usually taken at the end of the feasibility study. Funding for the process has to secure.

5) Detailed design

Complete detail design drawings and technical specifications are prepared with the short goal to proceed to construction. Project optimization is completed especially regarding hydraulic studies are finalized. A complete set of drawing for construction (to be formally released during procurement) is produced. A final cost estimate at +-10-15% is prepared. Procurement of long-lead items and pre-qualification of contractors is conducted. Procurement is subsequent to this phase and can be done simultaneously. Engineering support is provided during procurement to review questions, addendum and for proposal review.

Regulatory approvals are obtained during this process and funding is made available. Acquisition of land has to be finalized and construction preparation starts. Environmental and regulatory commitments and mitigations have to start to be implemented, if applicable.