Jun 7th, 4:25 PM - 4:45 PM

Session D6 - Modeling fish passage response to instream flows on run-of-river hydroelectric projects

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Modelling fish passage response to instream flows on run-of-river hydroelectric projects

National Conference on Engineering & Ecohydrology for Fish Passage

June 7, 2012

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Hydro Potential in BC

Source: IPP Watch
Run-Of-River Projects

- 35 operating projects in BC
- 19 projects in assessment process
  - Ecofish - environmental services for 12 of 19
- More projects on the horizon
  - 8000+ potential sites

Photo: Clean Energy BC
Run-Of-River Hydro
Run-Of-River Hydro

Intake
Penstock
Weir
Transmission Lines
Powerhouse
Tailrace
Downstream
Diversion

Graph showing discharge (cms) from January to December 1995 for Upstream of Intake.

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Run-Of-River Hydro

- Intake
- Weir
- Penstock
- Transmission Lines
- Powerhouse
- Diversion
- Tailrace

Graph showing discharge (cms) over different months from Jan to Dec for Upstream of Intake (green) and Downstream of Intake (orange).
Run-Of-River Hydro

- Intake
- Weir
- Penstock
- Transmission Lines
- Powerhouse
- Diversion
- Tailrace
- Downstream
Diversion Reach

- High Gradient

Average Gradient 6.9%

Elevation (m) vs Distance (m)

Intake
Powerhouse

June 7, 2012
Diversion Reach

- **High Gradient**

**Average Gradient 6.9%**

Elevation (m)

Distance (m)

Intake

Powerhouse

0 3000

0 250
Diversion Reach

- High Gradient
- Confined

Average Gradient 6.9%

Elevation (m)

Distance (m)
Diversion Reach

- High Gradient
- Confined
- Up to 10 km long
Fisheries Act

Canadian scientists slam weakening of federal Fisheries Act

By PETER O'NEIL and LARRY PYNN, Vancouver Sun
Posted May 28, 2012

The legislation would eliminate one of the most powerful environmental components of federal law - the ban on any activity that results in "harmful" alteration, disruption or destruction of fish habitat.
Canadian scientists slam weakening of federal Fisheries Act

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The legislation would eliminate one of the most powerful environmental components of federal law - the ban on any activity that results in "harmful" alteration, disruption or destruction of fish habitat.

Migration will still be protected..

20. (1) If the Minister considers that doing so is necessary to ensure the free passage of fish or to prevent harm to fish, (f) maintain the flow of water that the Minister considers sufficient to permit the free passage of fish;
Pulse Flow Releases: Ash River, BC

Do pulsed flow releases enhance fish passage?

Base flow: 3.5 cms
Flow at 10 cms
Flow at 20 cms
Ash River Leap Counts
Ash River Leap Counts

![Graph showing average leaps per hour relative to control period at 10 cms and 20 cms with error bars. The error bars represent 95% Bootstrap C.I.](image)
Ash River Snorkel Counts

Model Evaluated September 7
Ash River Telemetry

Fish #46

Fish #44

Fish #50

Fish #43
Evidence suggests that pulse flows work on storage-type hydropower projects.

- How to design pulse flows under a run-of-river flow regime?
Pulse Flow Release Parameters

- Period for Releases
- Frequency
- Duration
- Magnitude
Migration Model
Migration Model

- Compartment Model
- Proportion of fish that pass obstacle = f(Q(t))
- Presence at obstacle requires passage of any obstacles further downstream
- Delay at obstacle:
  - Scenario Passage Date – Baseline Passage Date
  - Considers direct effect of obstacle plus delays at downstream obstacles
Fish Arrival
Fish Arrival Timing

![Graph showing fish arrivals per day by month.](image)
Tailrace
Tailrace

![Graph showing passage probability against percentage discharge diverted.](graph.png)

June 7, 2012
Tailrace

Baseline

Fish Passed

Discharge (cms)

Baseline

Scenario - No Pulse Flows

Baseline

Scenario - No Pulse Flows
Tailrace

Scenario - No Pulse Flows

Discharge (cms)

Fish Passed

Baseline

Scenario - No Pulse Flows
Tailrace

Scenario - No Pulse Flows

Delay

Baseline

Scenario - No Pulse Flows

Fish Passed

Discharge (cms)
Tailrace

Scenario - Pulse Flows

- Baseline
- Scenario - No Pulse Flows
- Scenario - Pulse Flows

Discharge (cms)

Fish Passed

J J A S O

0 20 40 60 80 100 120 140

0 5 10 15 20 25 30 35 40
Canyon
Canyon

![Graph showing passage probability vs discharge](image)

Discharge (cms)
Canyon

Baseline

Discharge (cms)

Fish Passed

Baseline

Scenario - No Pulse Flows

Scenario - Pulse Flows

Baseline
Canyon

Scenario - No Pulse Flows

Baseline

Scenario - No Pulse Flows

Baseline

Scenario - Pulse Flows

Baseline

Scenario - Pulse Flows

Baseline

Discharge (cms)

Fish Passed

Scenario - No Pulse Flows

Baseline

Scenario - No Pulse Flows

Baseline

Scenario - Pulse Flows

Baseline

Scenario - Pulse Flows

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Scenario - Pulse Flows

Baseline

Baseline
Canyon

Scenario - Pulse Flows

Discharge (cms)

Fish Passed

Baseline

Scenario - No Pulse Flows

Scenario - Pulse Flows

- Baseline
- Scenario - No Pulse Flows
- Scenario - Pulse Flows
Falls
Falls

![Discharge probability graph with a bell curve extending from 0 to 20 cms on the x-axis and passage probability ranging from 0 to 1 on the y-axis.]

*June 7, 2012*
Falls

Baseline

Discharge (cms)

Fish Passed

Scenario - No Pulse Flows

Baseline

Scenario - Pulse Flows

Baseline
Falls

Scenario - No Pulse Flows

Baseline

Scenario - Pulse Flows

Baseline
Falls

Scenario - Pulse Flows

Discharge (cms)

Fish Passed

Baseline
Scenario - No Pulse Flows
Scenario - Pulse Flows

Baseline
Scenario - No Pulse Flows
Scenario - Pulse Flows
Passage Success
Effect of Pulse Flows

No Pulse Flows

Pulse Flows

Average Delay (Days)

1975 1985 1995

120
100
80
60
40
20
0
-20

Tailrace  Canyon  Falls

1975 1985 1995

120
100
80
60
40
20
0
-20

Tailrace  Canyon  Falls
Design Parameters

- **Minimum flow release**
  - 7 cms
  - 10 cms
- **Flow release period**
  - 15-Jun to 15-Oct
  - 1-Jul to 30-Sep
- **Frequency of release**
  - 1 day of every 4
  - 2 consecutive days of 7
Average Delay (Cumulative)

Pulse Flow Frequency

1 Day of 4

2 Day of 7

Pulse Q Minimum (cms)

Pulse Q Minimum (cms)

01-Jul to 30-Jun

Sep

Oct

01-Jul to 30-

15-Jun to 15-

15-Jun to 15-

15-Jun to 15-
Average Delay (Cumulative)

**Pulse Flow Frequency**

- **1 Day of 4**
- **2 Day of 7**

<table>
<thead>
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<th>Pulse Q Minimum (cms)</th>
<th>Delay</th>
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<tr>
<td>7</td>
<td>0</td>
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<tr>
<td>10</td>
<td>20</td>
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**Pulse Flow Period**

- 01-Jul to 30-Jun
- 15-Jun to 15-Oct

*Note: Data points marked with an asterisk (*) indicate significant differences.*
Average Delay (Cumulative)

Pulse Flow Frequency

<table>
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</table>

1 Day of 4

2 Day of 7

01-Jul to 30-Jun

Sep to Oct

Pulse Flow Period

June 7, 2012
Average Delay (Cumulative)
Average Delay (Cumulative)

Pulse Flow Frequency

<table>
<thead>
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<th>Pulse Q Minimum (cms)</th>
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</table>

1 Day of 4

2 Day of 7

01-Jul to 30

15-Jun to 15-Oct
Cost of Flow Release (cms days)
Cost of Flow Release (cms days)
Conclusion

- Run-of-river hydro projects provide an opportunity to avoid some pitfalls associated with traditional facilities.
- Pulsed flow regimes can potentially facilitate fish passage through run-of-river diversion reaches.
- Our model provides a useful tool to incorporate hydrology and information on passage flows to select flow regimes to effectively facilitate fish movement under flow diversion conditions.
End
Thank you for your attention

Questions?

Contact: khealey@ecofishresearch.com