Jordan River Learning Lab
Lab Report 2: Testing the Direct Effects Hypothesis
January 2014

Statement of the problem

The Jordan River is located in northern Utah, where it flows approximately 51 miles north from Utah Lake to Great Salt Lake. The Jordan River is identified as impaired for a variety of parameters along its entire length. This Lab focuses on the lower Jordan. The lower Jordan is made up of reaches 1-3, which include the river from 2100 South north to the river's discharge to Great Salt Lake.

> In this Lab Report, we're addressing the following hypothesis: Increased flows during critical summer conditions could directly improve the dissolved oxygen levels in the stream.

The three reaches of the lower Jordan are listed as impaired due to insufficient dissolved oxygen (along with benthic macroinvertebrate problems and *E. coli*). The dissolved oxygen impairment harms the river's designated use for warmwater fisheries (Class 3B). The entire Jordan River is heavily flow-managed, and the lower Jordan is particularly impacted. A diversion canal at the beginning of the lower Jordan leaves as little as 10 or 20 percent of the natural flows in the Jordan River channel.

A Total Maximum Daily Load (TMDL) has been developed for the relevant reaches (i.e. reaches 1-3). The TMDL establishes loading limitations for Total Organic Matter (OM) in order to reach the target endpoint for dissolved oxygen.

In this Lab, we are investigating how changes to flow management might enhance efforts to achieve water quality criteria for dissolved oxygen, while also improving ecosystem function in the lower Jordan. For more on the problem, please see the Introduction to the Jordan River Learning Lab Reports.

Hypothesis

This Lab began with several hypotheses about how flow changes might help improve water quality. In this Lab Report, we're addressing just one of the hypotheses: Increased flows during critical summer conditions could directly improve the dissolved oxygen levels in the stream (while leaving the OM in place). In this scenario, simply providing a larger volume of water (and hence of dissolved oxygen) at the beginning of the impaired reaches would allow the entire stretch of river to comply with water quality criteria. We call this the direct dissolved oxygen effects hypothesis. We had many questions related to testing the direct effects hypothesis. These included:

1. Could increased flows directly help achieve dissolved oxygen water quality criteria?
2. If so, what flows would be required?

3. What would be the best timing (e.g., Spring? Fall?) and pattern for the flows?
4. What are the related threats and challenges? (e.g., Bank stability concerns? Flooding? Water rights implications?) What are the related benefits? (e.g., Improvements in habitat structure? Improvements in other parameters? Degradation?)

Materials

We worked with SWCA consultants to design and implement "Phase 1" of the Jordan River Lab. Phase 1 was designed to test the direct effects hypothesis, as well as several other hypotheses (see Jordan River Lab Report 1 for more an alternate hypothesis, called the scour hypothesis). Phase 1 materials included:

- An existing HEC-RAS model and an existing QUAL2K model
- Data from a wide range of sources, including the Utah Division of Water Quality (DWQ), the University of Utah, the U.S. Geological Survey (USGS) stream gages and National Water Information System (NWIS), Environmental Protection Agency (EPA) Storage and Retrieval Database (STORET), Salt Lake County, personal communications, and primary literature.
- An "advisory team" made up of River Network staff, our consultant from SWCA, representatives from Salt Lake City (which controls the Jordan River diversion), and a representative from Utah's Division of Water Quality.

Procedure

If you've read Lab Report 1, this procedure will sound familiar…or identical…as we used the same approach to test each hypothesis (e.g., the scour and the direct effects hypotheses).

River Network staff developed an initial set of hypotheses about how changing the flow on the river might affect water quality. We drafted up a short description of the problem, a list of possible outcomes (i.e., hypotheses), a list of questions about how the flow changes might play out, and a list of concerns that would need to be addressed (e.g., downstream water rights, flooding, etc.).

We then gathered together a small group of the key players on the issue to serve as our advisory team. This included both staff from Salt Lake City, which controls the diversion impacting the Jordan, and the Division of Water Quality, which developed the existing Total Maximum Daily Load for the river. We shared our write up with this group and discussed the ideas. Most importantly, we discussed how far Salt Lake City would be willing to go in increasing flows. The City suggested they would be open to significantly increasing flow (to as much as 750 cfs) if flooding concerns could be addressed and there was a real benefit to those increased flows.

From there, we worked with our advisory team to draft a request for proposals so we could hire a technical firm to model the situation on the Jordan. River Network (and the advisory team when appropriate) worked with the consultant to inform the modeling as it was conducted. The consultant modeled several different flow scenarios to illustrate how different scenarios supported (or didn't) our hypotheses. The consultant shared two drafts of the report with the advisory team, incorporated comments, and produced a final Phase 1 report. This report summarized the results of testing our hypotheses, suggested next steps, and laid out the road map for phase 2. Find the full report here: http://www.rivernetwork.org/jordan-river-learning-lab.

Results

Initial Phase 1 results suggest this hypothesis could be a winner! Results from the modeling effort suggest increasing flows in the lower Jordan River by as little as 25 percent should result in measurably higher dissolved oxygen levels. In fact, this type of modest flow increase could result in compliance with water quality criteria for dissolved oxygen. See the chart on the next page for a visual representation of various flow regimes.

While there are uncertainties associated with our initial findings (see next section for details), we decided this hypothesis was clearly worth pursuing.

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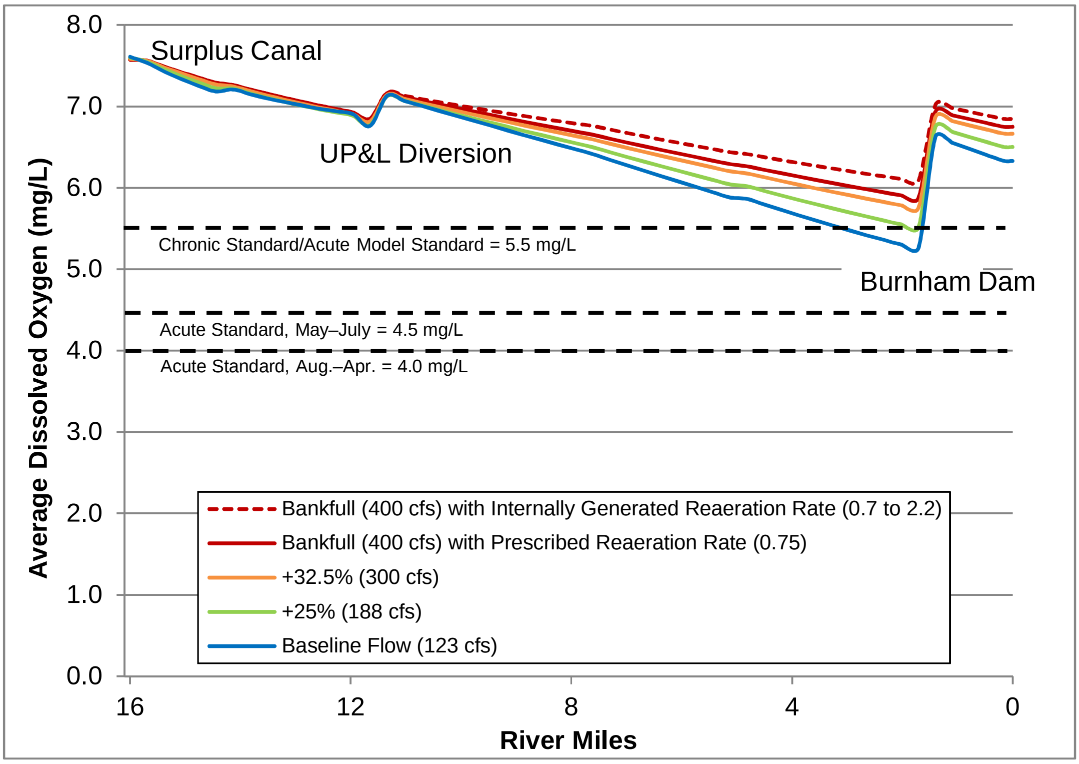
Figure 1: Sensitivity of model to changing flow conditions. (Figure from "Lower Jordan River: Phase 1 Report" by SWCA).



Note: Flow rates in parentheses are the flows just downstream of the Surplus Canal. Percentages show increased flow percent above model baseline. The model baseline flow of 123 cfs violates the chronic DO standard of 5.5 mg/L. By increasing flows to the lower Jordan by 25%, chronic violation is prevented. Internally generated reaeration rate runs are only shown at bankfull flow for clarity, but at every flow, DO levels were higher than using prescribed rates.

Uncertainties

There are several types of uncertainties related to our results. First, the model was built around limited data from a limited time window. Secondly, the prescribed reiteration rate used in the model was determined from a one-time measurement made in September 2009. Phase 2 investigations (see "next steps") are designed to reduce our uncertainties by addressing both of these limitations.

Conclusions

Although there are some uncertainties associated with the test of our direct effects hypothesis, the results show that increasing flows in the Lower Jordan could be a powerful tool for improving water quality in the river. We shared our results with Salt Lake City and others involved with decisions about water quality and with flow management, and those key leaders agreed.

Next steps

Next steps (Phase 2) focus on making our model findings robust enough to provide Salt Lake City and others with the confidence they need to commit to experimental flow releases (Phase 3). This work includes:

1.) *Developing Phase 2 of work around the direct effects flow/dissolved oxygen hypothesis.* The project is currently developing a Phase 2 of the project, which will include updating and validating a QUAL2Kw modeling approach around this hypothesis. In addition, we will investigate other possible ecosystem benefits to increasing flows in the lower Jordan. A future Lab Report will summarize Phase 2's results.

2.) *Designing proposed experimental flow releases (Phase 3).* As part of Phase 2, we will propose scenarios for flow releases to allow us to monitor water quality improvements and other benefits (or problems). If all goes well, we may conduct releases as early as summer 2014. As early as fall 2014 we may be reporting on the results of experimental flow releases!

3.) *Working to understand water rights implications.* At the same time as we develop Phase 2 of the research, staff will be working with local stakeholders to educate them about the possible flow releases, and to better understand the water rights implications of any proposed changes. As anyone who works with western water law knows, this is a complicated arena. However, initial work with stakeholders suggest there

Some lessons learned to date…

Acknowledge your limitations up front. We decided to work within flow scenarios that Salt Lake City and Salt Lake County had already indicated were acceptable. Given the highly developed nature of the area and other water rights limitations, we decided to focus on flow changes that were likely to be acceptable to water managers. This doesn't mean information about natural flows was or will be ignored, but our scenarios focused on relatively modest changes in flow.

Don't put all your eggs in one basket. Implementing the project in phases allowed us to investigate several hypotheses at a relatively superficial level while saving the bulk of our project dollars for a more in-depth phase 2 look at whatever turned out to be the most promising hypothesis.

Try to limit initial data and modeling costs. Phase 1 of the project worked only with existing models and data to limit costs until we were more certain one of the hypotheses was worthy of deeper testing. We were lucky to be able to work with existing (though limited) models developed for other purposes (i.e., the TMDL and flooding issues).

are ways forward…we just have to work diligently to find those paths and make sure others are comfortable walking them with us. Again, stay tuned for a future Lab Report on lessons learned through this work.