Jordan River Learning Lab
Lab Report 1: Testing the Scour Hypothesis
December 2013

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.

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 (with specific volume, timing, and duration) could move OM off the river bed, moving the OM downstream and depositing it in areas where it could be relatively easily removed. Removing at least some of the OM would reduce its ability to lower dissolved oxygen in the Jordan River's water column, moving the river closer to compliance with water quality standards. To summarize in an if/then statement: If we increase flows in the lower Jordan, then organic matter will be removed from the system and we will see associated improvements in dissolved oxygen. We call this the "scour hypothesis."

> In this Lab Report, we're addressing just one possible hypothesis: Increased flows could move organic matter off the river bottom, moving it downstream and depositing it in concentrated areas where it could be relatively easily removed.

We had many questions related to testing the scour hypothesis. These included:

1. Could increased flows suspend and transport the problematic OM?
2. If so, what flows would be required to suspend and transport the problematic OM?
3. Where would the OM be deposited? What would ultimately be the fate of that OM? (e.g., Would it cause more harm in its new location? Would it be collectable/removable?)
4. What would be the best timing (e.g., Spring? Fall?) and pattern (e.g., pulses?) for the flows?
5. Beyond the initial flushing or flushings, is there an on-going flow regime that would help maintain the channel and water quality?
6. 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 scour hypothesis, as well as several other hypotheses (see Jordan River Lab Report 2 for more on the direct effects flow/dissolved oxygen hypothesis). Phase 1 materials included:

- An existing HEC-RAS model and an existing QUAL2K model
- Additional 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

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 how different scenarios effected (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

From initial modeling results it appears that increasing flows in the Lower Jordan is unlikely overcome cohesion in the river's sediments, and so is unlikely to scour OM from the system. When compared to literature values for critical shear stress (a measure of the minimum amount of shear stress required to initiate soil particle motion), model results for the Jordan predict that in most instances the shear stresses will not reach the critical levels that would result in scour.

Even if model results suggested more potential for scour, there is some risk in exposing deeper sediments in the lower Jordan.

Even if model results suggested more potential for scour, there is some risk in exposing deeper sediments in the lower Jordan River. Estimated sediment oxygen demand rates for lower sediments are predicted to be generally the same or higher than rates in upper sediments. In addition, there is a potential for excavating relic hazardous chemicals generated historically during times of greater industrial activity and less regulatory control.

Table 1: Summary of Bed Shear Stress[1]

Segment	Literature Values Shear (lb/ft^2)	Average Shear (lb/ft^2)		Minimum Shear (lb/ft^2)		Maximum Shear (lb/ft^2)	
		200 cfs	Bankfull	200 cfs	Bankfull	200 cfs	Bankfull
2100 S to UP&L diversion	0.12-0.63	0.09	0.13	0.01	0.02	0.46	0.46
UP&L diversion to I-215 bridge	0.12-0.63	0.08	0.09	0.004	0.01	0.52	0.52
I-215 bridge to Burton Dam	0.12-0.63	0.03	0.04	0.004	0.01	0.06	0.06

Note: shading indicates only results within literature value range.

[1] Table excerpted from full report.

Uncertainties

There are several types of uncertainties related to our results. First, the critical shear stress values were based on a review of literature values, not on actual data about the Jordan River's sediments. In addition, the literature values found were insufficient in scope and indicated a large variability in critical shear stress based on site conditions. Site-specific shear stress values would need to be collected to resolve these issues.

Secondly, our understanding of sediment oxygen demand (and possibly toxic parameters) in the lower sediments is based on a regression analysis based on work in the upper sediments. If we wanted to address concerns about scour flows simply exposing sediments with the same or more dramatic oxygen demand, this approach would need to be validated through an actual analysis of the sediment cores.

Conclusions

Although there are uncertainties associated with the test of our scour hypothesis, we feel the data shows relatively little opportunity for improving water quality in the Lower Jordan by "flushing" or scouring organic matter from the system. However, our final report identifies additional ideas that could be followed up on in order to reduce the uncertainties and that may in fact show the idea has merit for the lower Jordan. It is important to note two things:

1.) *Although the scour hypothesis did not stand up for the Jordan, it may be valid in other river and stream systems.* If you are interested in the idea in your watershed, consider the types of information and tools described in this Lab Report. Can you muster similar data and tools in your watershed? Do you have information that would address the uncertainties which limited our ability to quantify the ability to move organic matter? Do you know enough about your historical sediments to feel more comfortable than we could that you won't be unburying sediments that are as worrisome (or worse!) than what you currently have?

2.) *We did find data to support an alternative hypothesis relating flow management to our goals.* All is not lost. Because we designed a phased project which did not put all of our eggs in the scour hypothesis basket, our project did find a

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).

supportable approach. In a nutshell, initial results show increasing flows by a modest amount during critical summer conditions can directly improve the dissolved oxygen levels in the stream (while leaving the OM in place). This alternate hypothesis is known direct effects flow/dissolved oxygen hypothesis. For more on those exciting findings, see Jordan River Lab Report 2.

Next steps

Our next steps focus on 1.) summarizing our findings related to this scour hypothesis in case other researchers would like to follow up on the idea and 2.) developing work around an alternative hypothesis regarding how flow will directly improve dissolved oxygen levels in the Lower Jordan River.

1.) *A final report from phase 1 contains a more detailed summary of our results and recommendations related to the scour hypothesis.* The report will assist other researchers who might be interested in addressing some of the uncertainties in our scour analysis. Resolving these uncertainties may result in more promising findings related to the scour hypothesis. However, for the purposes of our project, we are not pursuing the scour hypothesis.

2.) *Developing phase 2 of work around the alternative direct effects flow/dissolved oxygen hypothesis.* The same phase 1 report which summarizes our findings on the scour hypothesis reports promising findings on our alternate hypothesis. The project is currently developing a phase 2 (and perhaps 3) of the project, which will include updating and validating a QUAL2Kw modeling approach around this hypothesis and – excitingly – pilot flow releases to test the model results in the real world. See Jordan River Lab Report 2 for more information.