Version 1.3

Comparison between two Macroinvertebrate Assessments in Lower Mill Creek

Technical Report

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<u>Submitted to:</u>
Jordan River/ Farmington Bay Water Quality Council
Salt Lake City, UT, USA

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Summary

Lower Mill Creek was listed as 'impaired' by UDWQ (2012/2014 Integrated Report) in part for O/E bioassessment which was based entirely on two composited benthic macroinvertebrate assemblage data collected on a single date, November 9, 2009. A listing of 'impaired' has important ramifications for CVWRF operations. Additional macroinvertebrate sampling was therefore justified to supplement and verify these important UDWQ conclusions. OreoHelix Consulting, Moab, UT and River Continuum Concepts Manhattan, MT collected sixteen macroinvertebrate samples from Lower Mill Creek upstream of CVWRF discharge and twenty samples downstream of CVWRF discharge in 2014 and 2015, identified, analyzed, and compared these results with UDWQ results.

Multivariate analyses showed that macroinvertebrate assemblages in November are clearly different than assemblages that occur during spring and summer and that assemblages upstream and downstream of CVWRF discharge significantly differ from each other. UDWQ 2009 identified 23 macroinvertebrate taxa *upstream* of the discharge which was significantly more than were collected by Richards and Marshall (mean = 16). UDWQ 2009 estimated macroinvertebrate density upstream of the discharge at 2269/m^2, whereas Richards and Marshall estimated mean density at 9108/m^2. More importantly, UDWQ 2009 estimated density downstream of the discharge of only 177/m^2, whereas Richards and Marshall estimated mean downstream density at 2073/m^2. The proportions of dominant taxa also differed between the two studies as did the very important but often misinterpreted water quality metric, EPT taxa.

Even though it is clear that Lower Mill Creek is biologically impaired; observed low taxa richness (the O in O/E) compared to expected values (the E in O/E) can be largely explained by the type of habitat found in Lower Mill Creek, mostly low gradient, fine particle substrate (silt, sand, clay, etc.) as compared to riffle habitats that are used to derive O/E calculations. Riffle habitats are targeted for sampling by UDWQ because riffles have 'the greatest diversity of bug species in stream ecosystems". Low gradient, fine particulate sediments typically have far fewer taxa and species composition than riffle habitats. This alone could have substantially lowered O/E scores for Lower Mill Creek.

November sampling can result in biased estimates, including those that are used for O/E calculations. UDWQ recommends sampling between May and October. Results from this report support that recommendation. The five to six years' difference between UDWQ and Richards and Marshall sampling events also likely had an effect. Typically, the number of taxa at a location does not vary as much annually as do densities.

Another factor resulting in the discrepancies between UDWQ and Richards and Marshall taxa richness estimates and indeed between UDWQ upstream and downstream taxa richness estimates was the number of individuals examined. There is a well known relationship between the number of individuals identified and the number of taxa found. Richards and Marshall used a standard 300 organism count regardless of the number of individuals collected, whereas UDWQ 2009 examined 100% of the 1679 individuals collected in the single composited *upstream* sample and 100% of the mere 131 individuals collected in the single composited *downstream* sample. This relationship alone can explain why UDWQ reported that there were 'significantly' fewer taxa

occurring downstream of CVWRF discharge than upstream, including EPT taxa. However, there seems to be no explanation as to why UDWQ found so few individuals downstream of the discharge.

In addition, replication is required to estimate any error associated with sampling including taxa richness and density estimates. It is not possible to determine if a sample was truly representative of a site (e.g. the UDWQ downstream density estimate) without replication (i.e. UDWQ single sample upstream and single sample downstream).

Also, Salt Lake County regularly dredges Lower Mill Creek as part of its flood reduction program. Dredging clearly removes benthic invertebrates and macrophytes. Reestablishment may take many generations. Sections of Lower Mill Creek may have been dredged sometime prior to UDWQ's sampling in 2009 and affected their results and conclusions.

Results presented in this report and in Richards (2016 in prep) support UDWQ's 2012/2014 findings that Lower Mill Creek is biologically impaired but the reliance on O/E as the sole criterion may have clouded UDWQs conclusions and may possibly have over estimated the level of impairment. There was no evidence that the section of Mill Creek downstream of CVWRF discharge was in poorer biological condition than the upstream section, contrarily, Richards (2016 in prep) suggests that biological condition may be slightly better downstream than upstream as a result of the discharge.

Introduction

Lower Mill Creek Assessment Unit (confluence Jordan River to I-15) was listed as impaired for dissolved oxygen and O/E bioassessment in UDWQ's 2012/2014 Integrated Report. O/E bioassessments are based entirely on benthic macroinvertebrate assemblage data and the UDWQ impaired listing for Lower Mill Creek was based on only two macroinvertebrate samples collected on November 9, 2009; one composited sample collected upstream of CVWRF discharge but downstream of the Union Pacific rail yard bridge crossing and another composited sample collected downstream of CVWRF discharge and upstream of the confluence with the Jordan River. A listing of 'impaired' has important ramifications for CVWRF operations, as do conclusions on the effects of CVWRF discharge on Mill Creek by UDWQ based only on two samples. Additional macroinvertebrate sampling was therefore justified to supplement and verify these important UDWQ conclusions.

CVWRF and the JR/FBWQC contracted Dr. David C. Richards, Ph.D. at OreoHelix Consulting, Moab, UT to collect macroinvertebrate samples in Mill Creek and to analyze results produced by Brett Marshall, River Continuum Concepts Taxonomic Lab, Manhattan, MT (referred to as Richards and Marshall in the rest of this memo). Results from OreoHelix Consulting/River Continuum Concepts were compared with results from UDWQ 2009 sampling.

Methods

Field Sampling

One square meter area benthic macroinvertebrate samples using D- net with 500-micron mesh were collected upstream and downstream of CVWRF discharge in Mill Creek between May 2014 and November 2015 in habitats proportional to their occurrence (Table 1). Samples were not composited. UDWQ November 9, 2009 data used in this comparison were from samples that followed UDWQ protocols, which included compositing of eight samples into one, and focused sampling efforts on riffle habitat.

Table 1. Dates and number of samples collected upstream and downstream in Lower Mill Creek, and in the Jordan River downstream of confluence with Mill Creek.

	Upstream	Downstream	Jordan River
28May2014	3	3	6
20August2014	4	8	0
20Nov2014	5	5	0
25August2015	4	4	0

Laboratory Methods

River Continuum Concepts, Manhattan, MT, conducted standardized 300 count subsampling and identified macroinvertebrates to a higher resolution than used by UDWQ. The higher resolution was decided on because many taxa in Lower Mill Creek occur in the Family Chironomidae and each chironomid taxon responds to environmental conditions differently and thus provided much more useful information than subfamily resolution. UDWQ only identifies Chironomids to the subfamily level. RCC then calculated the most widely used water quality metrics for each sample.

Statistical Analyses

A previous NMS multivariate analysis was conducted on the Richards and Marshall, May and August 2014 samples and the UDWQ 2009 November samples prior to the additional sampling that occurred in November 2014 and August 2015. Results of those analyses are presented in this report. Simple comparisons of taxa richness, density, Percent Dominant Taxa, and EPT taxa were then made between all currently available data, including those samples reported in Table 1 and the UDWQ 2009 November samples. UDWQ apparently collected additional samples from Lower Mill Creek in 2014. Those results have been requested from UDWQ but were not available at the time of this report and will subsequently be included in any future analyses.

Results

Previous NMS multivariate analyses clearly showed that macroinvertebrate assemblage based on UDWQ 2009 November samples were much different than those analyzed by Richards and Marshall (Figure 1). Additional NMS results using all of Richards and Marshall samples but excluding UDWQ samples are presented in an *in prep* Richards document (Richards 2016). These multivariate results also show that macroinvertebrate assemblages in November are clearly different than assemblages that occur during spring and summer and in addition, that upstream and downstream assemblages significantly differ from each other.

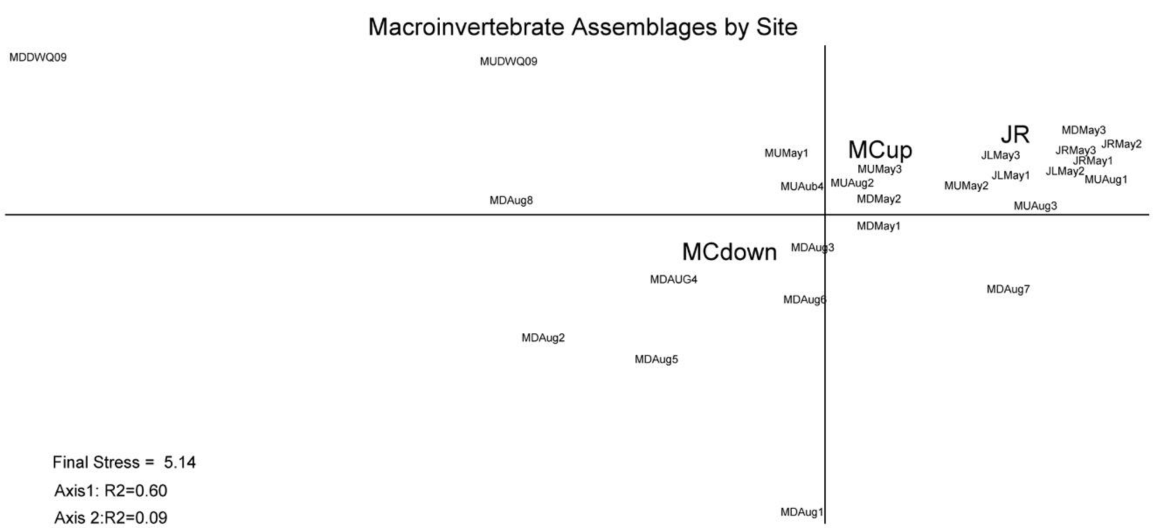

Figure 1. NMS of macroinvertebrate assemblage samples collected and analyzed by Richards and Marshall 2009 and UDWQ 2009. The two UDWQ samples are labeled MDDWQ09 located in the far upper left quadrant and MUDWQ09 located in the mid-upper, left quadrant. The UDWQ downstream sample (MDDWQ09) was extremely different than all of the other samples, which suggests it was a possible outlier.

Taxa Richness

The UDWQ 2009 *upstream* sample identified 23 macroinvertebrate taxa, whereas their *downstream* sample reported 15 taxa. This was significantly more than were collected by

Richards and Marshall in the upstream section but similar to the downstream section (Figure 2, z-test: 8.49, p = 0.000).

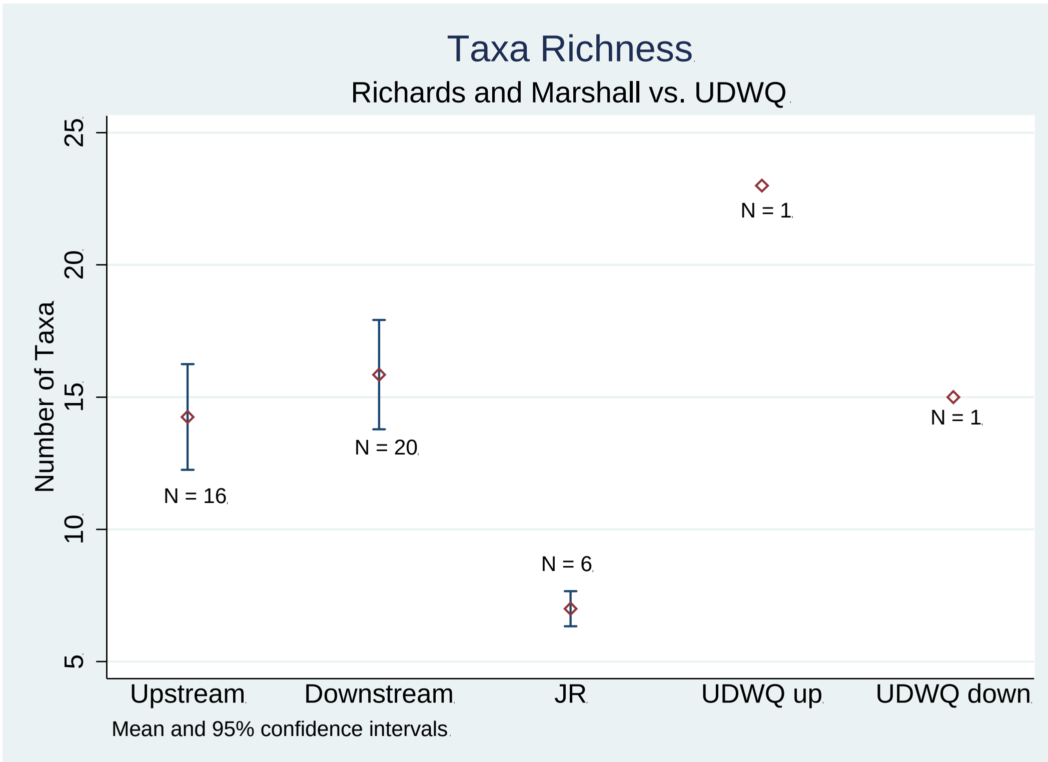

Figure 2. Estimated mean and 95% CIs taxa richness from Richards and Marshall and UDWQ sample data.

Table 1. Two sample z-test between UDWQ 2009 and Richards and Marshall upstream taxa richness estimates.

```
. ztest var3, by(var1)

Two-sample z test
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
DWQ	1	23	1	1	21.04004	24.95996
Upstream	16	14.25	.25	1	13.76001	14.73999
diff		8.75	1.030776		6.729715	10.77028

```
    diff = mean(DWQ) - mean(Upstream)                              z =   8.4887
Ho: diff = 0

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(Z < z) = 1.0000         Pr(|Z| > |z|) = 0.0000          Pr(Z > z) = 0.0000
```

Estimates of taxa richness by month, year, and location from the Richards and Marshall data are in Figure 3. As a comparison with UDWQ 2009 November samples, Richards and Marshall results estimated mean taxa richness at 16 upstream and 14 downstream with no significant differences found between upstream and downstream samples (Figure 3 and Richards in prep).

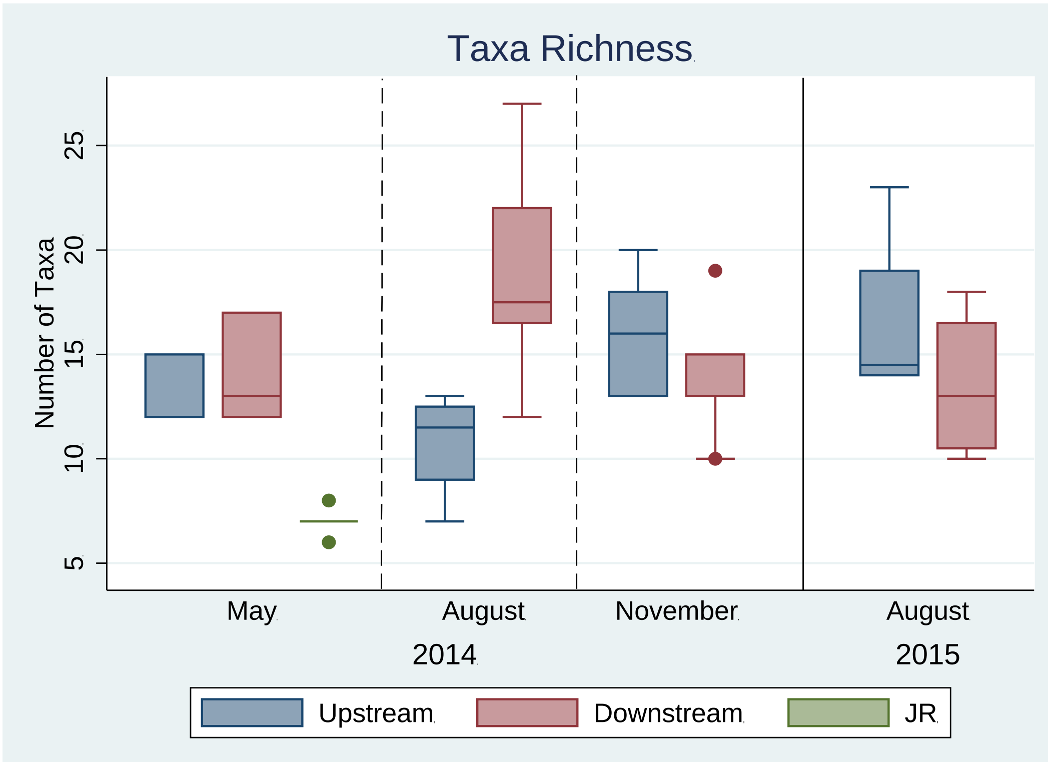

Figure 3.Taxa richness for Richards and Marshall data. Box plots include median, 25th percentile, 75th percentile, ranges, and outliers.

Density

The UDWQ 2009 *upstream* sample had an estimated density of 2269/m^2, whereas Richards and Marshall estimated upstream mean density = 9108/m^2 (3703 std. dev., median = 8093, 25th = 7050, and 75th = 11615/m^2). The UDWQ 2009 downstream sample had an estimated density of only 177/m^2, whereas Richards and Marshall estimated mean density was 2073 (std. dev. = 1161, median = 2262, 25th = 1521, 75th = 2580/m^2).

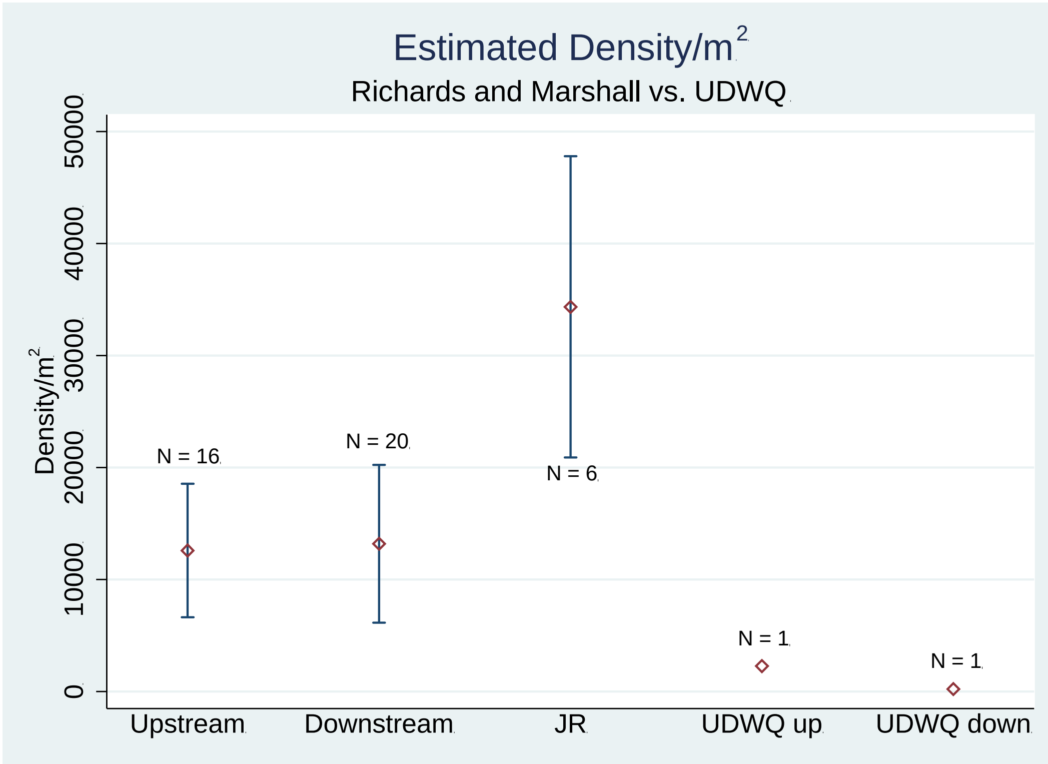

Figure 4. Estimated mean and 95% CIs macroinvertebrate densities/m² from Richards and Marshall and UDWQ sample data.

Mean and 95% CI estimates of densities by month, year, and location from the Richards and Marshall data are in Figure 5, with no significant differences found between upstream and downstream (Richards in prep).

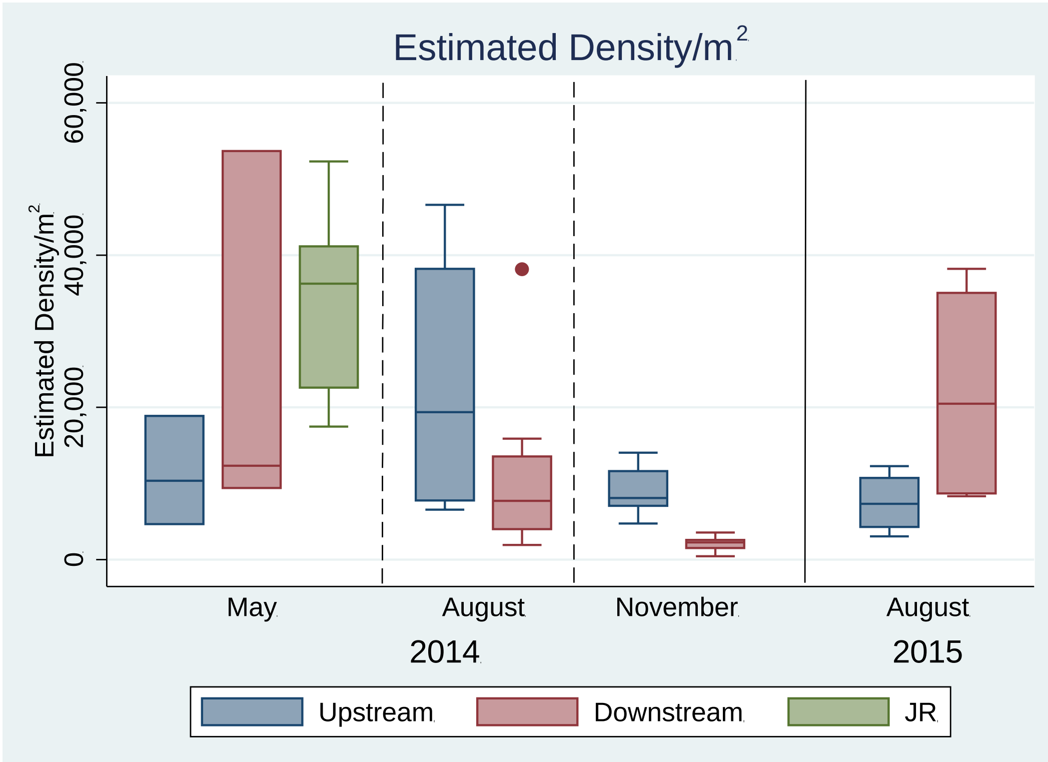

Figure 5.Estimated macroinvertebrate densities/m^2 from Richards and Marshall data. Box plots include median, 25th percentile, 75th percentile, ranges, and outliers.

Dominant Taxa

The two most dominant taxa in the DWQ Nov 2009 *upstream* sample were Turbellaria (52.2%) and Oligochaeta (24.2%) and the three most dominant taxa in the UDWQ Nov 2009 *downstream* sample were Psychoda (30.5%), Turbellaria (23.7%), and Physa (16.0%). The two most dominant taxa in the Richards and Marshall upstream samples were Oligochaeta (82.0%) and Cladocera (6.3%) and the three most dominant taxa in the downstream samples were Oligochaete (49.4%), Acari (26.3%), and Cladocera (6.7%).

EPT Taxa

One of the most used and abused water quality metric in bioassessments is EPT taxa, particularly for non- cold water, non-riffle habitats. EPT is the acronym for Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are in general sensitive to water quality impairments mostly because the majority of these taxa occur in cold, well oxygenated lotic riffle habitats. However, many of these taxa thrive in course sediments, slow flowing warm lotic habitat and even eutrophic lentic habitat, with the exception of Plecoptera which are almost exclusively cold water, well oxygenated, lotic inhabitants. An understanding of this is critical when using the EPT metric to evaluate the condition of a waterbody. Lower Mill Creek is not expected to support a rich EPT taxa assemblage and because of the lack of riffles, warm water, relatively low oxygen levels compared to mountain stream, no Plecoptera taxa are expected to occur. The ‘P’ in EPT should be eliminated from any assessment of waters such as Lower Mill Creek from the start of any thoughtful assessment.

Ephemeroptera Taxa

The only Ephemeroptera taxon found in Lower Mill Creek, upstream or downstream of CVWRF discharge by either UDWQ 2009 or Richards and Marshall was the cosmopolitan *Baetis* sp. UDWQ 2009 reported *Baetis* sp at 2.20% of the macroinvertebrate assemblages upstream of the discharge and they did not find any downstream of the discharge. Richards and Marshall findings are in Figure 6. *Baetis* sp. is one of the most common mayfly genera in North America, has multiple generations per year (multivoltine) and is highly mobile, it is classified as a ‘swimmer’ and can sometimes be misidentified as a small fish when swimming. It also can be either extremely abundant or sparse depending on conditions, generations, or seasons. *Baetis* sp. were most abundant in Richards and Marshall samples that were collected in May and were not found in November (Figure 6). August samples also had low densities of *Baetis* sp (Figure 6). As with many short lived taxa, over the course of sampling events by Richards and Marshall, *Baetis* sp. was mostly not encountered except in the May samples when it was abundant (Figures 6 and 7). Therefore, only May samples were statistically compared between upstream and downstream. There was no significant difference between upstream and downstream densities of *Baetis* sp. in May.

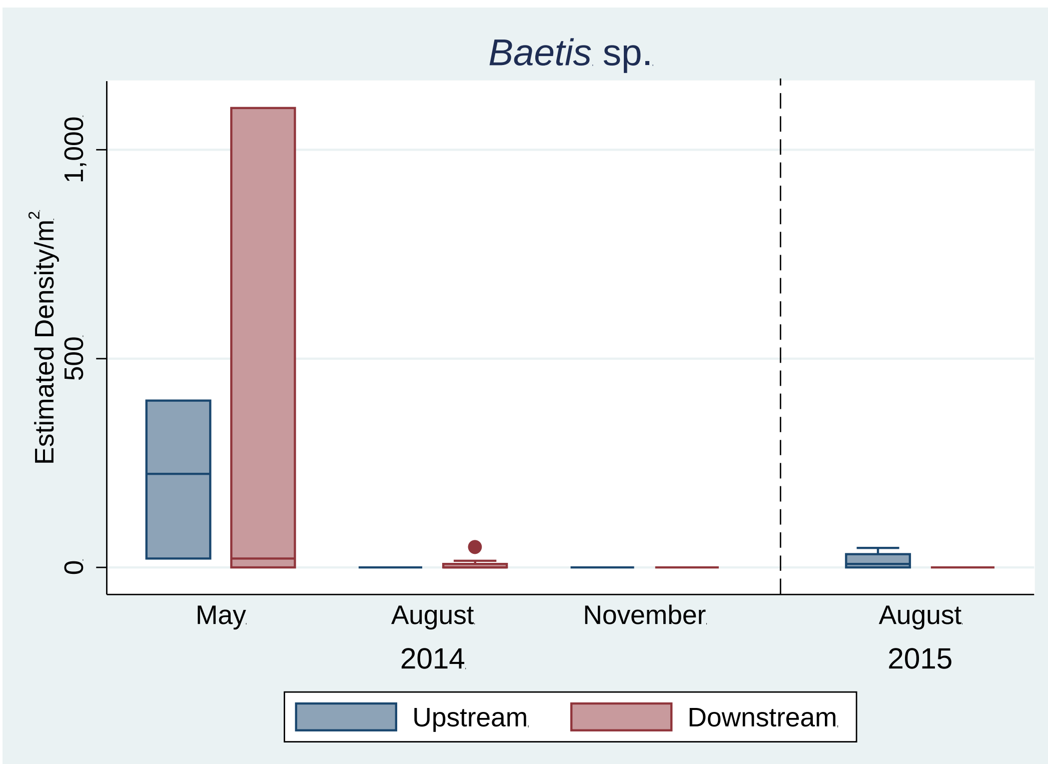

Figure 6. Estimated Baetis sp. densities/m^2 from Richards and Marshall data. Box plots include median, 25th percentile, 75th percentile, ranges, and outliers.

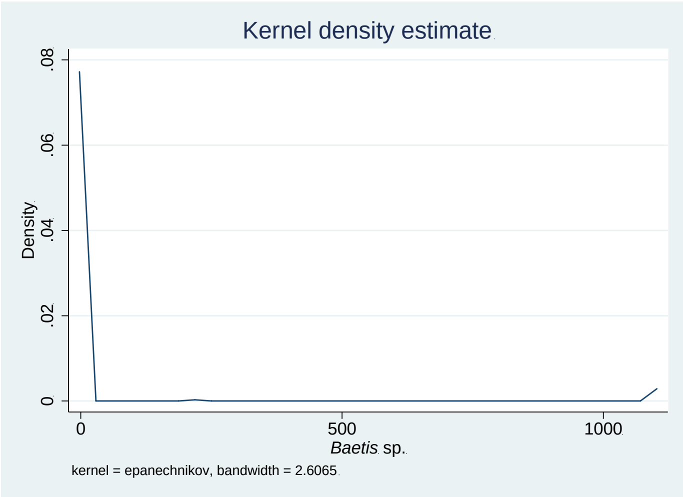

Figure 7. Distribution of Baetis sp. density in Lower Mill Creek using Richards and Marshall data.

Trichoptera Taxa

Two Trichoptera genera were encountered by Richards and Marshall, *Hydropsyche* sp. and *Hydroptila* sp. *Hydropsyche* sp. was most abundant in August 2014 (Figure 8), whereas *Hydroptila* sp. was most abundant in the August samples (Figure 9). Neither *Hydropsyche* sp. (Kruskal-Wallis chi square = 0.69, p = 0.41 nor *Hydroptila* sp. (Kruskal-Wallis chi square = 0.45, p = 0.50) differed significantly between upstream and downstream sections. As was *Baetis* sp., both Trichoptera taxa densities were highly variable between seasons and years. *Hydroptila* sp. was abundant downstream and not found upstream in August 2014. *Hydroptila* sp. abundances (densities) were reversed in August 2015 where it was abundant upstream but not found downstream. UDWQ 2009 found only one individual *Hydropsyche* sp. and only one individual *Hydroptila* sp. in the upstream section of Lower Mill Creek. UDWQ 2009 did not find any individuals of either taxon downstream.

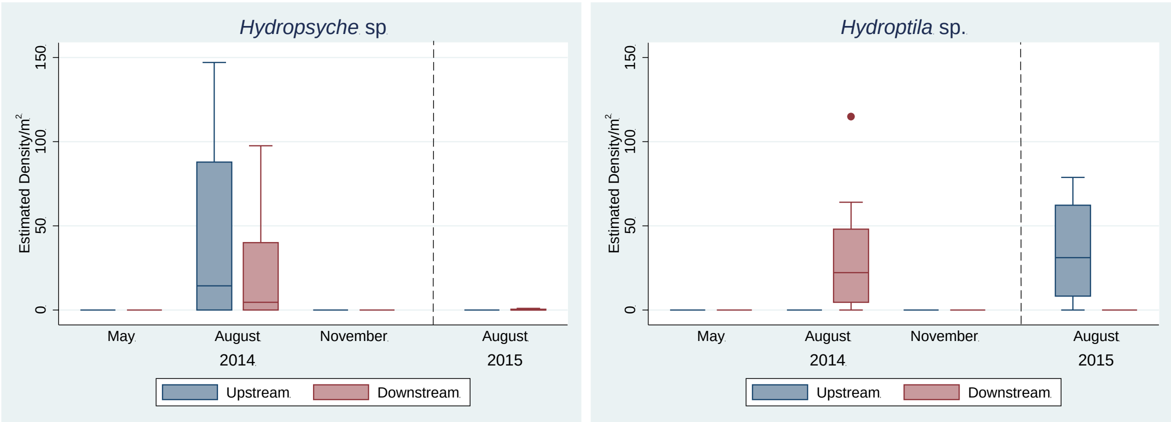

Figure 8. Estimated Hydropsyche sp .and Hydroptila sp. densities/m^2 from Richards and Marshall data. Box plots include median, 25th percentile, 75th percentile, ranges, and outliers.

Discussion

Clearly there were major discrepancies between Richards and Marshall results and UDWQ results, particularly upstream taxa richness estimates, downstream density estimates and proportions of dominant taxa. There are several explanations for these discrepancies:

Habitat

Perhaps the most important factor effecting taxa richness and density estimates was the types of habitat sampled. Both UDWQ and Richards and Marshall sampled primarily in non-riffle habitat, although UDWQ encourages sampling in riffle habitats as stated in their Field Operations Manual (UDWQ 2014a) methods:

> "The reason riffle habitat is targeted is because these conditions tend to yield the greatest diversity of bug species in stream ecosystems. A key factor of the UCASE program, in general, is capturing bug diversity at sites. Riffles tend to have more food flowing through them, as well as consistent temperatures and oxygen levels. Because riffles tend to be the shallower areas of a stream system, they tend to get more light which yields higher algae and diatom development. Algae and diatoms are a large food source for certain bug species. Also, since riffles tend to be in more constricted parts of the stream it forces objects to become more funneled and concentrated thus creating more food potential." (UDWQ 2014).

The upstream and downstream sections of Lower Mill Creek have very few riffle habitats. As a result, most benthic sampling is forced to occur in fine sediment, runs, or pool habitat. These types of habitat typically have fewer taxa naturally than riffle habitat.

Because Mill Creek downstream of the Union Pacific rail yard is mostly low gradient, homogenous, small particle, substrate with depths typically greater than riffle habitats, lower taxonomic diversity was to be expected than from riffle habitats. Even though Mill Creek is obviously impaired, as shown by Richards (2016) and UDWQ; basing O/E scores from samples collected in these types of habitats as compared to O/E scoring criteria developed primarily from riffle habitats is cause for concern. For example, it is virtually guaranteed that samples collected from pool habitats with fine sediments in high quality reference streams would have significantly lower O/E scores than those collected from riffle habitats in those same high quality streams.

Season and Year

Results showed that November macroinvertebrate assemblages are much different than spring and summer assemblages. This suggests that November sampling can result in biased estimates, including those that are used for O/E calculations. UDWQ recommends sampling between May and October (UDWQ 2014a) and results from this report support that recommendation. There was also five to six years' difference between UDWQ and Richards and Marshall sampling events. It is unknown how five to six years' differences effected results. Typically, the number of taxa at a location does not vary as much annually as do densities. This difference in years could also partially explain why so few Psychodid flies (0.1%) were found by Richards and Marshall in the downstream section in November compared with UDWQ's findings. Seasonality was also and important factor in determining the abundances (densities) of three important water quality taxa, *Baetis* sp., *Hydropsyche* sp. and *Hydroptila* sp. The highly variable nature of their abundances and in particular their typically low abundances in late autumn (e.g. November) likely influenced UDWQ evaluations.

Taxonomic resolution

Richards and Marshall taxonomic resolution was much greater for Chironomidae, which contrary to these results, should have resulted in more taxa than reported by UDWQ. However, a total of approximately fifty-six taxa were identified by Richards and Marshall in Lower Mill Creek. Taxa lists for both Richards and Marshall and UDWQ are presented in the appendices.

Sampling Effort

Abundance Richness Relationship

Another very important factor resulting in the discrepancies between UDWQ and Richards and Marshall taxa richness estimates and indeed between UDWQ upstream and downstream taxa richness estimates was the number of individuals examined. There is a well known relationship between the number of individuals identified and the number of taxa found; a similar relationship to the well known species area curve and expressed in the popular axiom, "the more you look, the more you find". Richards and Marshall used a standard 300 organism count regardless of the number of individuals collected, whereas UDWQ 2009 examined 100% of the 1679 individuals collected in the single composited *upstream* sample and 100% of the mere 131 individuals collected in the single composited *downstream* sample, a 12.8 times difference. This relationship alone can explain why UDWQ reported that there were 'significantly' fewer taxa occurring downstream of CVWRF discharge than upstream and in particular their conclusion that the "T"[1] in the EPT metric differed upstream and downstream (UDWQ 2014b). However, there seems to be no explanation as to why UDWQ found so few individuals downstream of the discharge. Perhaps they sampled directly in the effluent or that water depths and stream bank instability in the downstream section caused them to only sample in very shallow shoreline habitat that may have fluctuated regularly, thus limiting the number of resident invertebrates.

Number of samples

Replication is required to estimate any error associated with sampling and for estimating taxa richness and densities. Another statistical axiom unheeded, "replicate, replicate, replicate". Without replication, there is no way to determine if a sample was truly representative of a site (e.g. the UDWQ downstream density estimate). In addition, USEPA (2013, Page 5) typically frowns upon using one sample to evaluate taxa occurrences, "Perhaps the most important condition in defining species residency is that the taxa that occur at the site cannot be determined merely by a one-time sampling downstream and/or upstream of the site".

Dredging

Salt Lake County regularly dredges Lower Mill Creek from I-15 downstream to its confluence with the Jordan River as part of their flood reduction program. They remove many tons of substrate containing benthic macrophytes and invertebrates. Recolonization of the benthic community can take several generations, if at all. Some taxa such as Baetid mayflies can recolonize via downstream drift, while other poor dispersers such as the native mussel, *Anodonta*

[1] Trichoptera taxa (i.e. Hydropsyche sp. N = 1 individual upstream, and Hydroptila sp. N = 1 individual upstream)

sp. may never recolonize on its own. Most of the taxa found in the samples both upstream and downstream of the treatment facility were either short- lived multivoltine (several generations/year) or were rapid colonizing 'weedy' taxa. It appears that Lower Mill Creek is kept at an early successional stage due to recurring dredging by the county. It is possible that Salt Lake County dredged the section of Lower Mill Creek downstream of the CVWRF discharge sometime prior to UDWQ's 2009 sampling event and the benthic community, including macroinvertebrates and macrophytes, was not able to become reestablished. Salt Lake County dredging records need to be examined to help verify this supposition.

Regulatory Implications

The results presented in this report and in Richards (2016 in prep) support UDWQ's 2012/2014 finding that Lower Mill Creek is biologically impaired but the reliance on O/E as the sole criterion may have clouded UDWQs conclusions and may have over estimated the level of impairment. There was no evidence that the section of Mill Creek downstream of CVWRF was in poorer biological condition than the upstream section. Richards (2016 in prep) suggests that biological condition is slightly better downstream than upstream as a result of CVWRF discharge.

Literature Cited

Richards, D. C. 2016. *In Prep*. Mill Creek Use Attainability Analysis (UAA): Macroinvertebrates.

UDWQ. 2014a. Utah comprehensive assessment of stream ecosystems (UCASE): Field Operations Manual. Utah Department of Environmental Quality. Division of Water Quality. Salt Lake City, UT. 190 pages.

UDWQ. 2014b. Memorandum dated 7/24/2014. To: Dan Griffin et al. From: Ben Holcomb. Subject: Use Attainability Analysis (40 CFR 131.10(g).3) Initial Review of Lower Mill Creek−Receiving Water for Central Valley Water Reclamation Facility.

United States Environmental Protection Agency. 2013. Technical support document for conducting and reviewing freshwater mussel occurrence surveys for the development of site-specific water quality criteria for ammonia. EPA 800-R-13-003.

Appendices

*Appendix 1. UDWQ November 2009 macroinvertebrate data for Lower Mill Creek **upstream** of CVWRF discharge.*

TAXA NAME	TNUMB	DENSITY	Percent
Amphipoda	14	18.92	0.83
Baetis	37	50.00	2.20
Caecidotea	104	140.54	6.19
Ceratopogonidae	3	4.05	0.18
Chironominae	9	12.16	0.54

Coenagrionidae	20	27.03	1.19
Corisella	4	5.41	0.24
Corixidae	1	1.35	0.06
Diptera	4	5.41	0.24
Erpobdellidae	1	1.35	0.06
Gammarus	37	50.00	2.20
Glossiphonia complanata	2	2.70	0.12
Helobdella stagnalis	5	6.76	0.30
Hesperocorixa	2	2.70	0.12
Hydrobiidae	24	32.43	1.43
Hydropsyche	1	1.35	0.06
Hydroptilidae	1	1.35	0.06
Ischnura	19	25.68	1.13
Isopoda	10	13.51	0.60
Oligochaeta	406	548.65	24.18
Orthocladiinae	14	18.92	0.83
Physa	35	47.30	2.08
Pisidium	2	2.70	0.12
Sigara	26	35.14	1.55
Simulium	1	1.35	0.06
Sperchon	5	6.76	0.30
Tanypodinae	12	16.22	0.71
Trombidiformes	3	4.05	0.18
Turbellaria	876	1183.78	52.17

Appendix 2. UDWQ November 2009 macroinvertebrate data for Lower Mill Creek ***downstream*** *of CVWRF discharge.*

TAXA NAME	TNUMB	DENSITY	Percent
Caecidotea	2	2.70	1.53
Chironomidae	4	5.41	3.05
Chironominae	2	2.70	1.53
Coenagrionidae	1	1.35	0.76
Collembola	2	2.70	1.53
Erpobdellidae	1	1.35	0.76
Helobdella stagnalis	1	1.35	0.76
Hydrobiidae	2	2.70	1.53
Oligochaeta	10	13.51	7.63
Orthocladiinae	10	13.51	7.63
Physa	21	28.38	16.03

Psychoda	40	54.05	30.53
Simulium	3	4.05	2.29
Simulium vittatum group	1	1.35	0.76
Turbellaria	31	41.89	23.66

Appendix 3. Richards and Marshall November 2014 macroinvertebrate data for Lower Mill Creek with percent abundances

Upstream	Percent	**Downstream**	Percent
Oligochaeta	82.04	Oligochaeta	49.43
Cladocera	6.27	Acari	26.33
Micropsectra	1.94	Cladocera	6.66
Cricotopus/Orthocladius complex	1.89	Cricotopus/Orthocladius complex	5.86
Acari	1.87	Asellus	2.68
Microtendipes	1.34	Hydrobiidae	2.58
Cricotopus sylvestris gr.	0.84	Cricotopus sylvestris gr.	1.31
Collembola	0.55	Simulium	1.03
Corbicula	0.46	Potamopyrgus antipodarum	0.75
Hyalella	0.44	Ostracod	0.53
Pagastia	0.43	Collembola	0.40
Chironomidae	0.34	Microtendipes	0.40
Sphaeriidae	0.30	Hyalella	0.31
Ostracod	0.20	Hydroptilidae	0.29
Demicryptochironomus	0.19	Simuliidae	0.25
Asellus	0.17	Demicryptochironomus	0.24
Simuliidae	0.12	Paratrichocladius	0.21
Orthocladiinae	0.10	Corbicula	0.17
Palpomyia/Bezzia	0.10	Chironominae	0.10
Polypedilium	0.09	Prodiamesa	0.10
Empididae	0.07	Psychodidae	0.09
Hydrobiidae	0.07	Coenagrionidae	0.07
Chironominae	0.05	Sphaeriidae	0.07
Orthocladius	0.05	Chironomidae	0.06
Parakiefferiella	0.05	Eukiefferiella claripennis gr.	0.06
Hydroptilidae	0.03	Polypedilium	0.06

Appendix 4. Complete taxa list of macroinvertebrates collected in Lower Mill Creek and adjacent sections of Jordan River by Richards and Marshall

Acari

Alotanypus
Asellus
Baetis
Chironomidae
Chironominae
Chironomus
Cladocera
Coenagrionidae
Collembola
Copepoda
Corbicula
Cricotopus bicinctus
Cricotopus sp.
Cricotopus sylvestris gr.
Cricotopus/Orthocladius complex
Cryptochironomus
Demicryptochironomus
Dicrotendipes
Empididae
Eukiefferiella claripennis gr.
Glyptotendipes
Helobdella stagnalis
Hirudinea
Hyalella
Hydrobiidae
Hydropsyche
Hydroptila
Hydroptilidae
Lumbriculidae
Micropsectra
Microtendipes
Naididae (tubificid)
Nanocladius
Nematoda
Odontomesa
Oligochaeta
Orthocladiinae
Orthocladius
Ostracod

Pagastia
Palpomyia/Bezzia
Parakiefferiella
Paratanytarsus
Paratendipes
Paratrichocladius
Pericoma
Phaenopsectra
Physa
Polypedilium
Potamopyrgus antipodarum
Procladius
Prodiamesa
Psychodidae
Rheocricotopus
Simuliidae
Simulium
Sphaeriidae
Thienemanniella
Tricladida