Copper Flat Mine

Biological Assessment
November 2014

AquaticConsultants Inc.

"Your Lake & Stream Experts"

EXHIBIT

26

METHODS

All samples were collected and field measurements were completed on 06 November 2014. All testing was conducted by Aquatic Consulting & Testing, Inc. (Arizona Laboratory License No. AZ0004). Measurements and samples were collected from three locations (coordinates shown below) except where otherwise described.

Location 1:	N 32º58'11.97"	W 107º32'03.52"
Location 2:	N 32º58'15.24"	W 107º32'03.08"
Location 3:	N 32º58'14.48"	W 107º32'00.80"

Light transmission was measured using an Apogee MQ300 quantum meter and remote sensor. Transparency was measured using a standard Secchi Disk.

Temperature and oxygen profiles were measured using a YSI Model 550A dissolved oxygen meter with remote sensor. Light extinction coefficient was calculated using the quantum meter data and the following formula:

Light extinction coefficient $k = (\ln I_o - \ln I_d) \times 1/z$

Where k = extinction coefficient

I_o = light intensity at surface

I_d=light intensity at depth umhol/m^2/s [or uE]

Z= depth (m)

Water samples were collected from a depth of 0.5 meter at the three sampling locations and composited into a single sample. Depth-integrated samples were not required because the water was not vertically stratified. Sample preservation and chemical analyses were performed using EPA or APHA (Standard Methods) procedures licensed by Arizona Department of Health Services. Specific test methods are referenced in the attached laboratory reports. Algae identification and counts were made using a Nikon Diaphot phase/contrast inverted microscope. Samples were concentrated using an Utermohl settling chamber. Identifications were made using the following taxonomic references:

Baker, A.L. Algae, PS (Protista), Cyanobacteria, and Other Aquatic Objects. University of New Hampshire PhycoKey. http://www.cfb.unh.edu/phycokey/phycokey.htm.

Benson, C.E. and S.R. Rutherford. 1975. The Algal Flora of Huntington Canyon, Utah, U.S.A. A.R. Gantner Verlag, Germany. 177 pp.

Bold, H. and M.J. Wynne. 1985. Introduction to the Algae. Prentice Hall, Inc., Englewood, Cliffs, NJ. 720 pp.

Chapman, V.J. 1964. The Algae. St. Martin's Press, New York, NY. 472 pp.

Crawford, R.M., D.G. Mann, and F.E. Round. 1990. The Diatoms: Biology and Morphology of the Genera. Cambridge University Press, Cambridge, England. 747 pp.

Czarnecki, D.B. and D.W. Blinn. 1978. The Diatoms of the Colorado River. Strauss and Kramer. 181 pp.

Dillard, G.E. 1989. Freshwater Algae of the Southeastern United States. Vol. 1-6. J. Cramer, Berlin, Germany. 163 pp.

Dodd, J.F. 1987. Diatoms. Southern Illinois Press, Carbondale, IL. 477 pp.

Hein, M.K. 1990. Flora of Adak Island, Alaska: Bacillariophyceae (diatoms). J. Cramer. Stuttgart. 133 pp.

Patrick, R. and C.W. Reimer. 1966. The Diatoms of the United States. Monographs ANS No. 13, Vol. 1. Academy of Natural Sciences, Philadelphia, PA.

Patrick, R. and C.W. Reimer. 1975. The Diatoms of the United States. Monographs ANS No. 13, Vol. 2 Academy of Natural Sciences, Philadelphia, PA.

Prescott, G.W. 1978. How to Know the Freshwater Algae. William C. Brown Publishers, Dubuque, IA. 348 pp.

Prescott, G.W. 1962. Algae of the Western Great Lakes. William C. Brown Publishers, Dubuque, IA. 977 pp.

Rivers, I. 1978. Algae of the Western Great Basin. Desert Research Institute, Pub. 50008. University of Nevada, Las Vegas, NV. 390 pp.

Smith, G.M. 1950. Freshwater Algae of the United States. McGraw-Hill Book Company, Toronto,Canada. 719 pp.

Sze, P. 1986. The Biology of the Algae. William C. Brown Publishers, Dubuque, IA. 251 pp.

Tilden, J. The Myxophyceae of North America. Verlag Von J. Cramer, New York, NY. 328 pp.

University of Colorado. Diatoms of the United States. Diatom identification guide and ecological resource.

http://westerndiatoms.colorado.edu/

Warner, D. 1977. The Biology of the Diatoms. University of California Press, Berkley, CA. 498 pp.

Zooplankton was collected using an 80-um Wisconsin plankton net. A vertical tow from the bottom to top of the water column was made at each location and combined to produce a composite. At the laboratory, the concentrated sample volume was measured and recorded, an aliquot was transferred to a counting chamber, and the sub-sample was observed using a dissecting microscope. Zooplankton forms were identified and counted.

Benthic (sediment) samples were collected with a stainless steel Ponar dredge. The sediment was hand sorted and screened in the laboratory to retrieve and isolate macroinvertebrates. Particle size analysis was conducted using an ATM Arrow shaker equipped with stacked U.S. standard sieves.

Fish sampling was conducted using an 18' Smith-Root Electro-fishing Boat. Running Direct Current (DC) at 15 pulses per second. Percent of range selected was 40% with output at approximately 200 volts. Pulse width at 40% produced a pulse duration of 2.4 milliseconds. Electro-fishing amperage was between 8 and 10. Electro-fishing effort was continuous at 1800 seconds during daylight and 1800 seconds after dark. Additionally, three experimental mesh gill nets were deployed for 21 hours over night. Two sets were shoreline sets and one in the middle of the pit. Each net was 120ft long and made up of six monofilament 20ft sections with the following mesh sizes ½", 1",1 ½", 2", 2 ½", and 3".

RESULTS AND DISCUSSION

Physical Conditions

Stratification

Temperature and oxygen profiles are presented below. Water temperature measurements varied from 12.6 to 13.7 C and dissolved oxygen concentrations ranged from 8.9 to 9.4 mg/L. At the time of sampling, the pit water was vertically mixed. The greatest change in temperature with depth occurred at Location 2, with a change of only 0.7 C from top to bottom (7.5 m) of the water column. Accordingly, dissolved oxygen was essentially unchanged through the water column at each location, with only a 0.2 mg/L maximum change from surface to pit bottom. Raw data and profiles are presented in Figure 1.

The temperature and oxygen data, aside from other limiting factors, indicate the water should be supportive of a warm water or possibly a cold water fishery (summertime profiles were not available).

Transparency and Solar Radiation

The Secchi disk depth was approximately 4.0 m. PAR measurements indicated penetration through the entire water column. Approximately 110 umhol/m2/s PAR was available at the pit bottom (extinction coefficient 0.35). Sufficient light existed to support a phytoplankton population. Light intensity at the pit bottom was similar to the recommended light intensity for algae cultures (Lavens and Sorgeloos 1996) and possibly benthic algae, although the minimum light requirement for benthic algae is poorly understood (Stevenson et al 1996). Light extinction data and graph are presented in Figure 2.

Sedimentation and Substrate Type

The amount of compacted sediment on the pit bottom ranged from 4 to 6 inches, with up to a 20-inch covering of iron floc. The sediment contained a very low (0.21%) organic carbon concentration, but did contain organic nitrogen (2160 mg/kg) and phosphorus (880 mg/kg). These data indicate that benthic algae or even submerged rooted macrophytes could only exist in areas where the iron floc was limited (littoral zone).

Seive analysis (see Figure 3) indicated that all particles were less than 1.18 mm and 89 percent was finer than 0.6 mm. The sediment is classified as silt (all particles less than 2 mm). The silt provides little to no substrate for diversity in a macroinvertebrate population.

The sieve analysis is presented on the following page. Sediment chemistry data are presented as part of laboratory report package presented at the end of the narrative.

Nutrients

Low nutrient concentrations, typical of oligotrophic lakes, were measured. An available N:P ratio of 3:1 was found. Because of the low pH (4.6 SU) and reported (Hall Environmental Analysis Laboratory) acidity of the water (180 mg/L as $CaCO_3$), bicarbonate and carbonate ions would be essentially absent (Geller et al.). Sufficient inorganic carbon would be available to algae through the equilibrium reactions of absorbed atmospheric carbon dioxide and carbonic acid (University of Montana).

Biologically-available phosphorus (0.018 mg/L phosphate-P), nitrogen (0.24 mg/L NO_3-N and 0.03 NH_3-N) would be adequate to support a modest phytoplankton population. This projection was supported by the very low chlorophyll-a concentration measurement of 0.8 ug/L. At measured pH, no ammonia toxicity could exist. The low pH would be detrimental to cyanobacteria (blue-green algae growth, but not eukaryotic algae species (Brock 1973). The complete water quality report is provided at the end of the report narrative.

Biological Conditions

The pit waters contained a depauperate algal assemblage composed of only six genera of algae. The six consisted of the diatoms (Bacillariophyta) *Diatoma*, *Cymbella*, *Synedra,* and *Navicula*; the cryptomonad, *Cryptomonas*; and the blue-green (Cyanophtya) alga *Chroococcus*. *Cryptomonas* was the dominant organism and is common in cold, acidic waters (Holopaenin 1992; Ojala and Jones 1993). Diatoms have also been found in a number of acidic environments, especially where high concentrations of iron exist as in some pit water environments (Nicola 2000). *Chroococcus* has been reported to dominate acidified Canadian lakes (Seckbach 2007). The total cell count was 603 cells per mL. However, many of the diatoms were frustules only (no protoplasm or chlorophyll observed), suggesting that these were dead and settling cells. The viable cell count is estimated at 312 cells/mL. The algae composition is summarized below (Table 1).

Table 1. Algae composition of Copper Flat pit water 11/06/14

Genus	Division/ form	Count per mL	Percent Comp.
Diatoma	Bacillariophyta (diatom) unicell	22	3.7
Cryptomonas	Cryptophyta (cryptophytes) flagellate	223	37.0
Cymbella	Bacillariophyta (diatom) unicell	34	5.6
Synedra	Bacillariophyta (diatom) unicell	212	35.2
Navicula	Bacillariophyta (diatom) unicell	22	3.7
Chroococcus	Cyanophyta (blue-green) colony	89	14.8

Sediment samples, primarily in the littoral zone, contained diatom frustules (most void of protoplasm or chlorophyll) and a very small number of *Hormidium* (Chlorophyta) filaments. *Hormidium* grows in acid environments as low as pH 3.5 and is least susceptible to copper and zinc toxicity at the pH range of 3.5 to 4.0 SU (Hargraves and Whitton 1976).

No zooplankton were recovered from multiple vertical tows at each location.

No macroinvertebrates were recovered from the sediment.

No fish species were recovered from either electro-fishing or gill nets.

A very small stand (20 sq ft) of cattail (*Typha* sp.) was found along the lake edge, in the dampened soil. No floating or submerged macrophytes were present.

Integrated Conditions and Biological Integrity

Because of the limited variety of organisms recovered from the sampling activities, only a few basic indices were calculated to characterize the pit water. The indices typically characterize the pit water as oligotrophic, with insignificant amounts of organic pollution, but with one or more other water quality variables reducing productivity.

*Carlson Trophic Index (*Carlson 1976) uses chlorophyll-a, transparency and phosphorus concentration to quantitatively categorize the status of a lake ranging from oligotrophic (unproductive) to highly eutrophic (productive). The range of TSI was 28-69. Transparency and chlorophyll were indicative of an oligotrophic lake, but total phosphorus was characteristic of a eutrophic lake.

Nygaard Trophic Index (Nygaard 1976) proposed five indices to evaluate the organic pollution of water bodies based on the tolerance of various groups of planktonic algae occurring in them. These indices include Cyanophycean or Myxophycean index Chlorophycean index Bacillariophycean or Myxophycean index, Chlorophycean index, Bacillariophycean index, Euglenophycean index and a combination of these called compound coefficient index. Because of the paucity of phytoplankton, only the diatom index was appropriate. The Index value was 0, indicating oligotrophic conditions.

Palmer Organic pollution Index (Person 1989). The metric evaluates the degree of organic pollution based on pollution tolerance of key algal genera. The pit water score was 5 indicating minimal or no organic pollution, or that another variable is interfering with algae growth.

CONCLUSION

The collected and historic data demonstrate that the pit waters do not and cannot support a balanced ecosystem. Higher aquatic life forms are absent because of likely chemical toxicity, lack of suitable habitat, and lack of food resources.

The pH of the water is below the range (6.5 to 9.0 SU) typically considered supportive of aquatic ecosystems (EPA 1986). pH has been considered the most important determinant of water quality in a pit environment (Miller 2002), impacting divalent metals solubility and creating toxicity. Groundwater interaction with the walls and surrounding host rock of the pit create oxidation reactions that release sulfate, acid, and metals into the lake. Copper Flat Pit water pH (4.6 SU) is well below the typical tolerance range of most aquatic organisms and the copper concentration (18 mg/L) is well above minimum phytotoxic concentrations.

Although adequate light and some nutrients are available, there is a paucity of primary producers in the pit water. Without available food, zooplankton species are essentially absent. A high concentration of copper in the water and low pH appear likely factors limiting algal growth and survival.

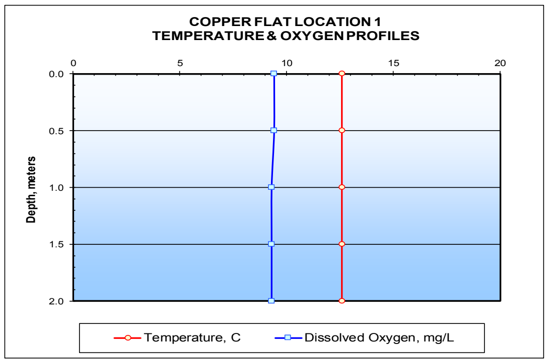
Macroinvertebrates are absent, including those typically considered tolerant of pollution. Habitat availability and diversity is limited. Most of the pit bottom and edge is composed of fine particulates; rocks and rubble are essentially absent. Organic matter is limited. The layer of precipitated iron covering a layer extremely fine silt is not suitable habitat for most benthic organisms. Food reserves for shredders and scrapers is highly limited, as the depauperate and sparse periphyton consisted of a single species of filamentous algae.

FIGURE 1

Copper Flat - 11/06/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 1

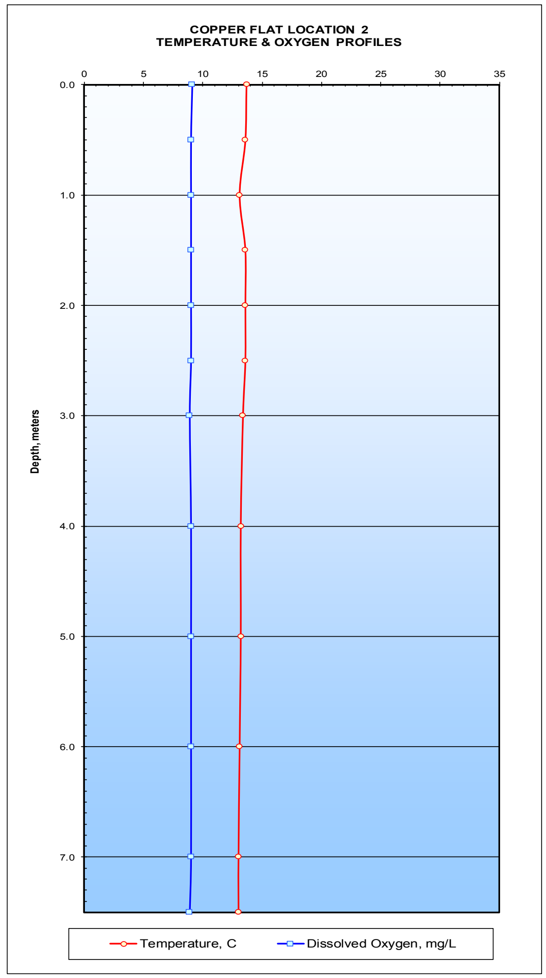
Depth, m	Temp, C	O2, mg/L
0.0	12.6	9.4
0.5	12.6	9.4
1.0	12.6	9.3
1.5	12.6	9.3
2.0	12.6	9.3



Copper Flat - 11/06/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 2

Depth, m	Temp, C	O2, mg/L
0.0	13.7	9.1
0.5	13.6	9.0
1.0	13.1	9.0
1.5	13.6	9.0
2.0	13.6	9.0
2.5	13.6	9.0
3.0	13.4	8.9
4.0	13.2	9.0
5.0	13.2	9.0
6.0	13.1	9.0
7.0	13.0	9.0
7.5	13.0	8.9



Copper Flat - 11/06/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 3

Depth, m	Temp, C	O2, mg/L
0.0	13.6	9.1
0.5	13.6	9.0
1.0	13.6	9.0
1.5	13.6	8.9
2.0	13.5	9.0
2.5	13.4	9.0
3.0	13.4	9.0
3.5	13.2	9.0
4.0	13.2	9.0

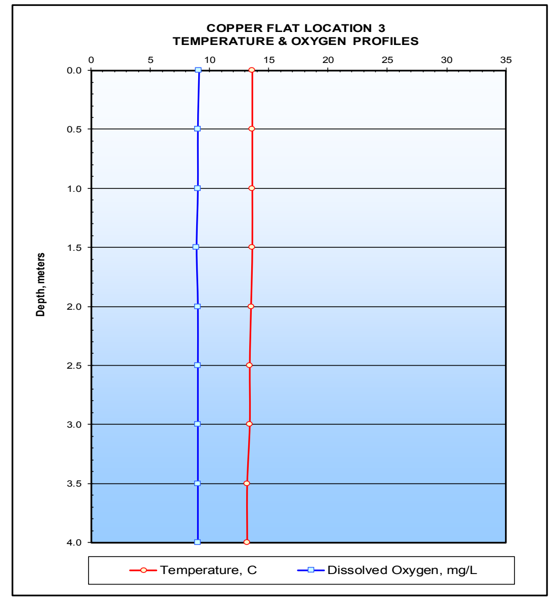
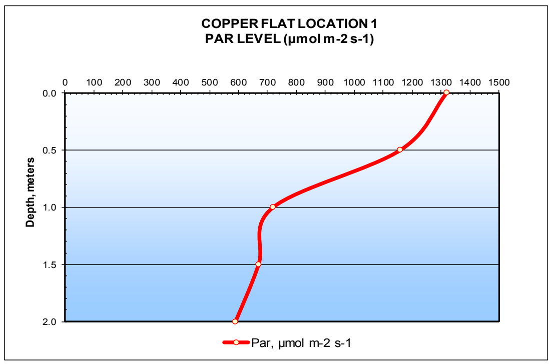


FIGURE 2

Copper Flat - 11/6/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 1

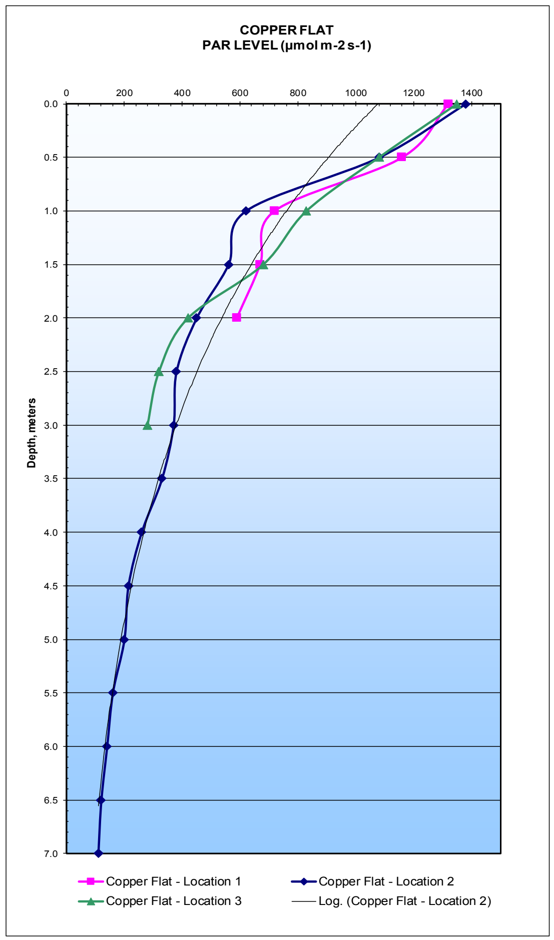
Depth, m	Par, µmol m-2 s-1
0.0	1320.0
0.5	1160.0
1.0	720.0
1.5	670.0
2.0	590.0



Copper Flat - 11/6/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 2

Depth, m	Par, µmol m-2 s-1
0.0	1380.0
0.5	1080.0
1.0	620.0
1.5	560.0
2.0	450.0
2.5	380.0
3.0	370.0
3.5	330.0
4.0	260.0
4.5	214.0
5.0	200.0
5.5	160.0
6.0	140
6.5	120
7.0	110



Copper Flat - 11/6/14
Aquatic Consulting & Testing, Inc.

Copper Flat - Location 3

Depth, m	Par, µmol m-2 s-1
0.0	1350.0
0.5	1080.0
1.0	830.0
1.5	680.0
2.0	420.0
2.5	320.0
3.0	280.0

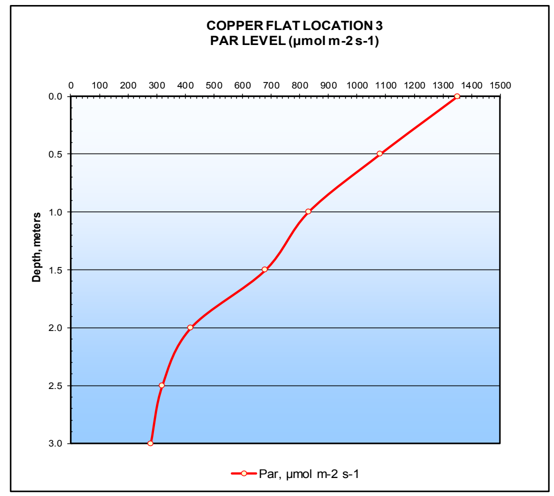
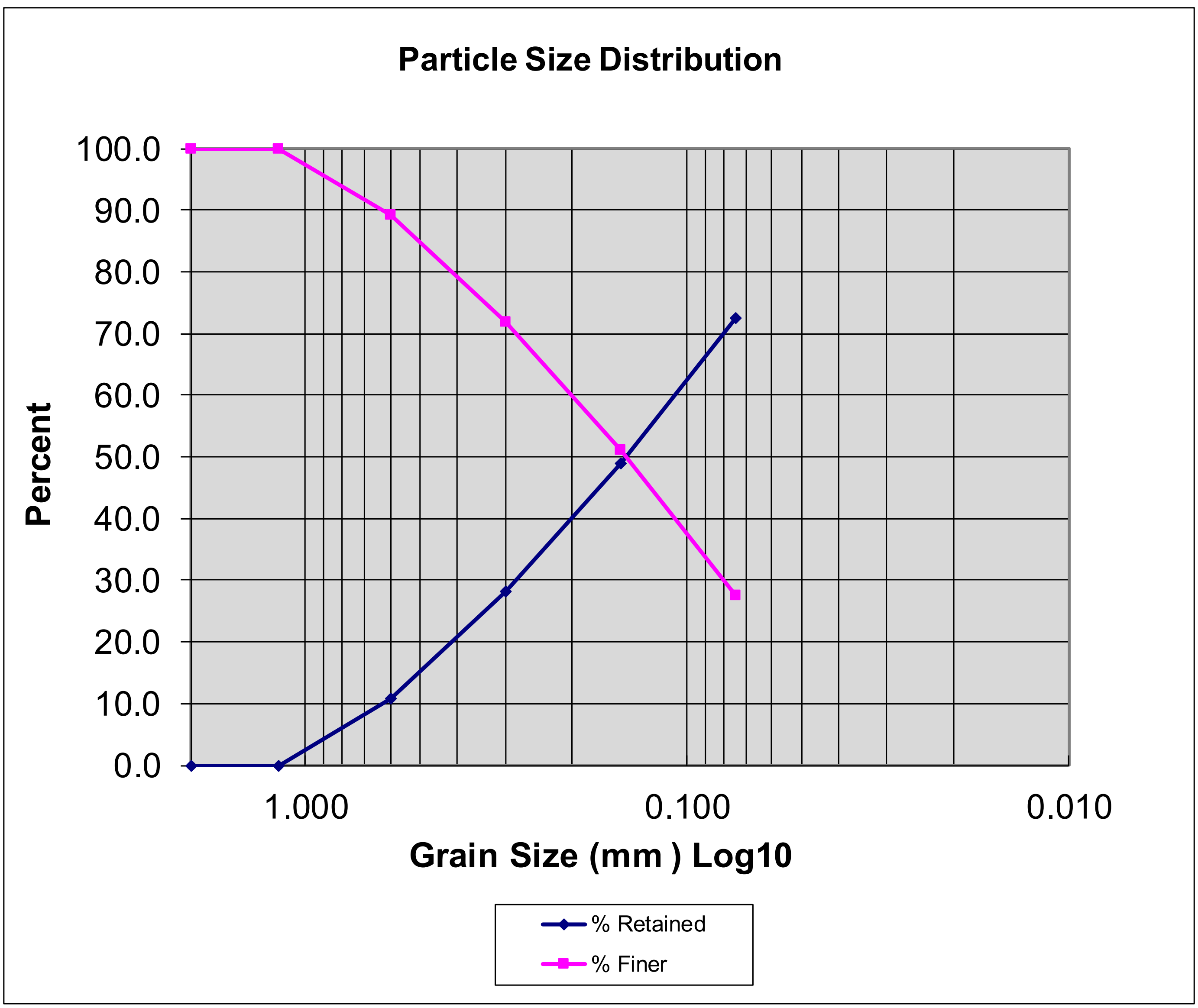


FIGURE 3

Laboratory ID: BW10543
Client ID: Aquatic Consultants - Copper Flat New Mexico

Mesh Size	Nominal Opening (inches)	Grain Size (mm)	Grams retained	Each sieve % Retained	Cumulative % Retained	% Finer
8	0.0937	2.360	0	0.0	0.0	100.0
10	0.0787	2.000	0	0.0	0.0	100.0
16	0.0469	1.180	0	0.0	0.0	100.0
30	0.0234	0.600	34.52	10.8	10.8	89.2
50	0.0117	0.300	55.01	17.3	28.1	71.9
100	0.0059	0.150	66.72	20.9	49.0	51.0
200	0.0029	0.075	74.76	23.5	72.5	27.5
	<0.0029		87.64	27.5	100.0	0.0



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Lic. No. AZ0003

LABORATORY REPORT

Client: Aquatic Consultants
4421 Irving Blvd. NW
Albuquerque, NM 87114

Date Submitted: 11/07/14
Date Reported: 12/02/14

Attn: Paul Cassidy

Project: Copper Flat

RESULTS

Client ID: H2O Comp. Loc 1-3
ACT Lab No.: SW10542

Sample Type: Surface Water
Sample Time: 11/06/14 14:30

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Total Organic Carbon	11/24/14	11/24/14	SM 5310 C	0.7	mg/L
Algae Count	12/01/14	12/01/14	SM 10200 F	See Attached	cells/mL
Algae Identification	12/01/14	12/01/14		See Attached	
Chl/Pheo Ratio	11/25/14	11/25/14	SM10200 H	1.14	
Chlorophyll a	11/25/14	11/25/14	SM10200 H	0.80	ug/L
Pheophytin a	11/25/14	11/25/14	SM10200 H	3.12	ug/L
Zooplankton	11/20/14	11/20/14	SM10200 G	<10.	#/cu. meter
Oxygen, Dissolved Field	11/06/14	11/06/14	SM4500 O G	9.0	mg/L as O2
pH, Field	11/06/14	11/06/14	SM4500H+ B	4.6	SU
Secchi Disk Depth	11/06/14	11/06/14	NALMS	4.0	meters
Temperature, Field	11/06/14	11/06/14	SM2550 B	13.6	C
Ammonia - N	11/20/14	11/20/14	SM4500NH3 D	0.03	mg/L as N
Nitrate + Nitrite - N	11/26/14	11/26/14	SM4500NO3 E	0.24	mg/L as N
Phosphate, ortho	11/07/14	11/07/14	365.3	0.018 *	mg/L as P
Phosphorus, Total	11/25/14	11/25/14	365.3	0.067	mg/L as P
Total Inorganic Carbon	11/24/14	11/24/14	SM 5310 C	0.9	mg/L
Total Kjeldahl Nitrogen	11/20/14	11/20/14	SMNorg C,NH3 C/D	0.3	mg/L as N

* R12=RPD/RSD exceeded the method acceptance limit. Result <5 times the PQL.

RESULTS

Client ID: Sed Comp. Loc 1-3
ACT Lab No.: BW10543

Sample Type: Sediment
Sample Time: 11/08/14 14:30

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Soil TOC	11/19/14	11/19/14	WalkleyBlack	0.21	% Org-C
Sieve Test	11/25/14	11/25/14	ASTM	See Attached	
Kjeldahl Nitrogen - Soil	11/19/14	11/19/14	SM4500NorgC mod.	2160.	mg/kg as N
Nitrate + Nitrite - N	11/18/14	11/18/14	SM4500NO3E mod.	<1.	mg/kg as N
Phosphorus, Total	11/23/14	11/24/14	365.3 mod.	550. *	mg/kg as P
Total Solids	11/10/14	11/14/14	SM2540 G	10.8	%

* R9-Sample RPD exceeded the method acceptance limit.

Client ID: Sed Floc
ACT Lab No.: BW10544

Sample Type: Sediment
Sample Time: 11/08/14 14:30

Parameter	Analysis Date Start	Analysis Date End	Method No.	Result	Unit
Microscopic Identification	12/01/14	12/01/14		See Attached	

Reviewed by: [signature]
Frederick A. Amalfi, Ph.D.
Laboratory Director

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CHAIN OF CUSTODY

PWS ID #________

PAGE___ OF___

Client Name: Aquatic Consultants, Inc.
Address: Street ______ City, State, Zip ______
Phone: ______
Fax: ______
Contact: Paul Cassidy
Sampler Signature: SPH

PO# Copper Flat
Project ______
Remarks:

SAMPLE ID	SAMPLE Date	SAMPLE Time	SAMPLE TYPE	Metals (See Below)	☐ TDS ☐ TSS ☒ TS ☐ SETT ☐ TVS ☐ VSS (per)	☐ O-G ☐ TPHC ☐ MBAS ☐ CN ☐ Sulfide	☐ BOD ☐ COD ☐ New Source	☒ Tot-P ☐ O-PO4 ☒ Diss. P	☒ Nitrate + Nitrite ☐ Nitrite	☒ TKN ☒ Ammonia	TOC, IOC	☐ Phenol ☐ 420.1 ☐ 625 ☐ 8270	TKN, Nitrate, TP	☐ Perchlorate ☐ Radio ☐ Asbestos	Total Coliform ☐ P/A ☐ Colilert ☐ MPN	TOC (w-s)	Fecal Coliform ☐ MPN ☐ MF	☒ MICRO SCOPE ID	Particle Size	F-(pH, DO, T, SDE)	Periphyton	Macroinvert	Chl a, Algae ID & Ct	Zoop.	No. of Containers: Na2S2O3	H2SO4	HNO3	NONE	Lugol	NaOH/ZnAc	Laboratory Number
H2O Comp. Loc. 1-5	11/6/14	1430	SW					X	X	X	X		X							X			X	X		1		5	2		BW-10542
Sed Comp. Loc. 1-3	↓	1430	Sed		X								X			X			X			X						1			43
Sed. Floc		1430	Sed															X										1			44
Edge Periphyton	↓	1540	Solid																	X	X							1			45

Metals: ☐ Al ☐ Sb ☐ As ☐ Ba ☐ Be ☐ B ☐ Cd ☐ Ca ☐ Cr ☐ Co ☐ Cu ☐ Au ☐ Fe ☐ Pb ☐ Mg ☐ Mn ☐ Hg ☐ Mo ☐ Ni ☐ Se ☐ Ag ☐ Na
☐ Sr ☐ Tl ☐ Sn ☐ Ti ☐ V ☐ Zn

[ ] TOTAL [ ] DISSOLVED [ ] SDWA [ ] TCLP [ ] RCRA

Sample Types: DW, GW, SW, WW, AQ, Soil, Sludge or Solid

Sample Receiving: MLL
Intact: X Yes ___ No
Temp: 15°C Auth Init: ____
Pres: 1 Yes/V 10 No/Lab
Sterile: ___ Yes X No
Total # containers: 11

1. Relinquished By: Sandy P. Hale	2. Relinquished By:	3. Relinquished By:
Date: 11/7/14 Time: 1507 AM/PM	Date: Time: AM/PM	Date: Time: AM/PM
1. Received By: T. Johnson	2. Received By:	3. Received By:
Date: 11-7-14 Time: 15:07 AM/PM	Date: Time: AM/PM	Date: Time: AM/PM

Attn: Your signature on this document authorizes analysis regardless of sample condition at time of submittal

White-Laboratory Yellow-Report Pink-Client

Sample delivery group #: -023