

TROMPE DESIGN, CONSTRUCTION AND PERFORMANCE

2016 National Meeting of the
American Society of Mining and Reclamation
Spokane, WA
June 9, 2016

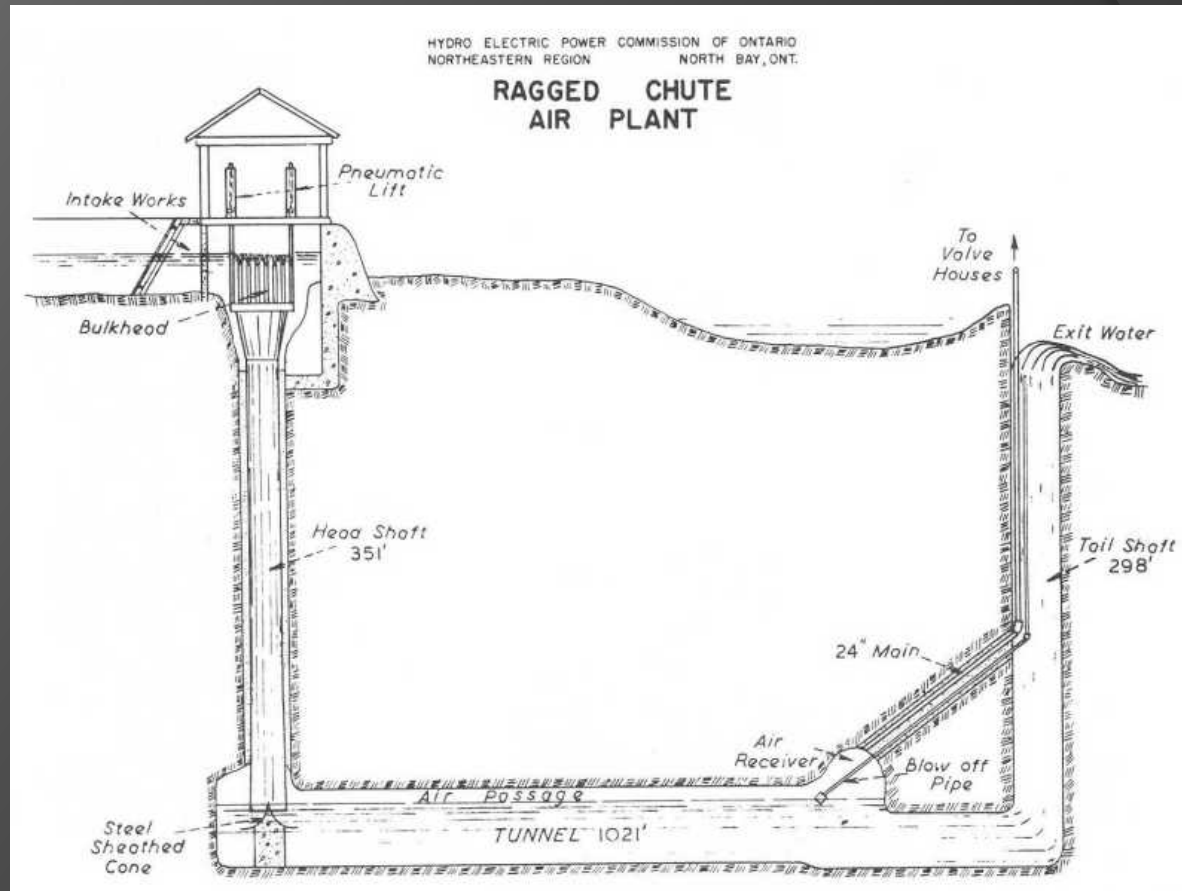
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DEDICATION



This presentation is dedicated to **Mr. Bruce Leavitt**.
It is his spirit, drive and dedication to improvement that has allowed us enjoy this amazing technology once again.

WHAT IS A TROMPE?



A trompe is a type of hydraulic air compressor which have no moving parts and uses the energy of falling water to compress air. Originally developed in 17th Century Italy

EARLY DEVELOPMENT



Bruce Leavitt built a prototype trompe in his backyard in Oct. 2010. The technology was quickly deployed at a mine drainage treatment site in Fayette County, PA in Jan. 2011.

OSM-FUNDED RESEARCH



OSM Applied Science Program Cooperative Agreement S11AC2033
<http://www.osmre.gov/programs/tdt/appliedscience/projects.shtm>

OSM-FUNDED RESEARCH



Size:	2"	3"	4"
GPM	17 – 24	49 – 91	84 – 140
ICFM	0.9 – 1.5	1.5 – 3.5	2.2 – 5.7
ICFM/100GPM	5.3 – 6.3	3.1 – 4.6	2.4 – 4.3

Tested 2", 3", & 4" Trompes (Size = Downpipe Diameter)

OSM-FUNDED RESEARCH



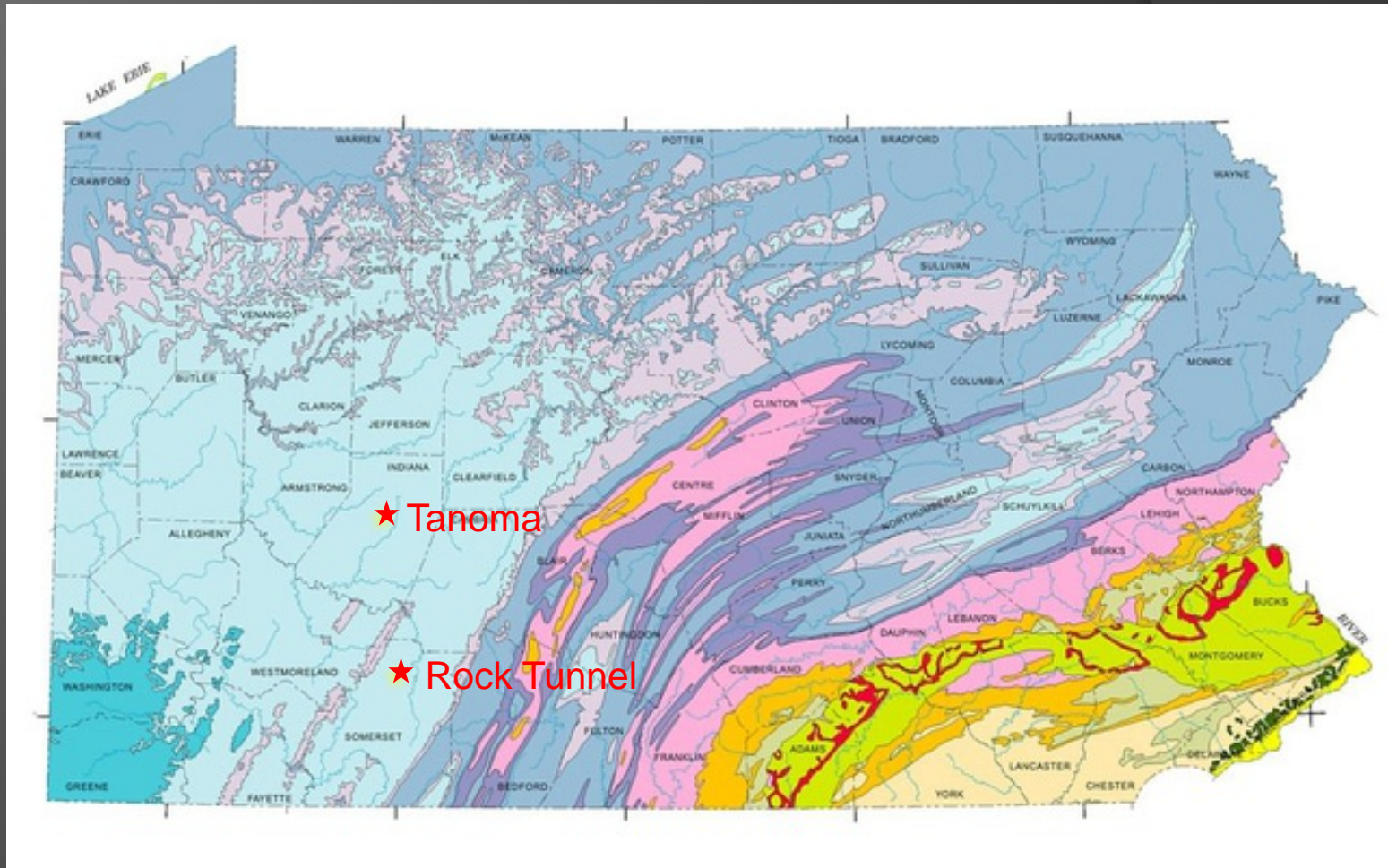
Field demonstration site – North Fork Montour Run
Montour Run Watershed Association
Allegheny County Airport Authority (Pittsburgh Airport)

OSM-FUNDED RESEARCH



Field demonstration site – North Fork Montour Run
Three triple-inlet 2.5” trompes in series (~50-150 GPM)
Typical Performance: 10 ICFM / 115 GPM

ROCK TUNNEL & TANOMA



Both ~3,000 GPM Alkaline Coal Mine Drainage
Rock Tunnel ~3 mg/L Fe [] Tanoma ~9 mg/L Fe

SCALING UP 20X



4" Downpipe



4" Trompe = 17 1/2" CTS CPVC air tubes
10" Trompe = 71 1/2" SCH40 SS/Al air tubes
Sum of air tube OD = Appx 1/2 Downpipe ID



10" Downpipe

ROCK TUNNEL



Rock Tunnel Passive Treatment System (1994/2014 rebuild)
Somerset County Conservation District
Somerset County, PA (700-3100 GPM; Alkaline Fe ~3 mg/L)
Three 10" Trompes in parallel - **Design Flow: 3,000 GPM**

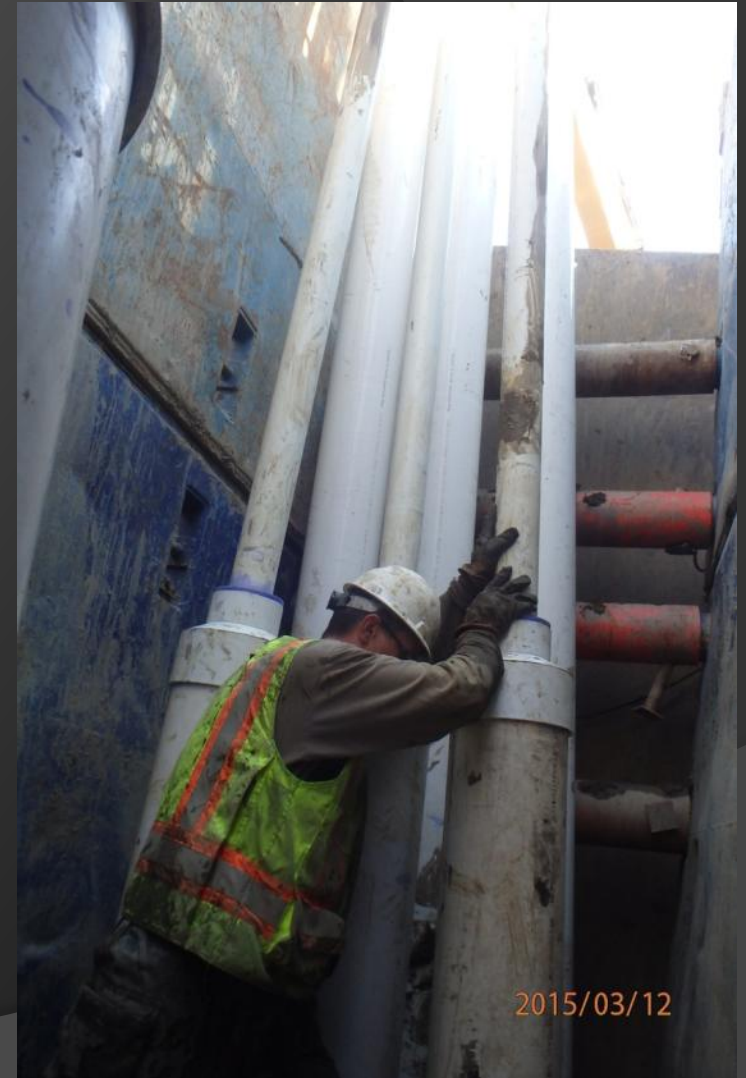
ROCK TUNNEL



15' Deep Hole 10' from stream

2015/03/12

ROCK TUNNEL



Vertical pipes between shoring

ROCK TUNNEL



Three 10" trompes in parallel (10" Downpipe & 10" Uppipe)

ROCK TUNNEL



Shoring removal

ROCK TUNNEL



Trompe system

ROCK TUNNEL



Inlet control for variable-flow sequential operation

ROCK TUNNEL



3,000 GPM trompe-powered aeration

TANOMA



Tanoma Passive Treatment System (2000)

Evergreen Conservancy

Indiana County, PA (200-3700 GPM; Alkaline Fe ~9 mg/L)

Three 10" Trompes in parallel -
Design Flow: 3,000 GPM

TANOMA



Hole excavation

TANOMA



Pre-fab separation chamber

TANOMA



Photo by: Kelsea Palmer, St. Francis Univ.

Separation chambers with uppipes and air chambers

TANOMA



1,300' 4" Air line with positive drainage

TANOMA



Air line manifold

TANOMA



Trompe system

AIR MEASUREMENT



Kanomax Model A004 Anemometer (20 – 3940 FPM)
2" tube adapted to outside of air induction head

FLOW MEASUREMENT

TANOMA **TIMER SET TO 60 SECONDS** **10" PIPE BY FLOW METER**

Equation: $V = (0.9008)(\pi)(0.012)(R)(\text{Revolutions Per Second}) \cdot 7.48 \cdot 60 = CFS \times 44.833 = GPM$

COUNT	GPM	COUNT	GPM	COUNT	GPM	COUNT	GPM	COUNT	GPM	COUNT	GPM	COUNT	GPM	COUNT	GPM
1	12	51	206	101	401	151	596	201	791	251	986	301	1,181		
2	15	52	210	102	405	152	600	202	795	252	990	302	1,185		
3	19	53	214	103	409	153	604	203	799	253	994	303	1,189		
4	23	54	218	104	413	154	608	204	803	254	998	304	1,193		
5	27	55	222	105	417	155	612	205	807	255	1,002	305	1,197		
6	31	56	226	106	421	156	616	206	811	256	1,006	306	1,201		
7	35	57	230	107	425	157	620	207	815	257	1,010	307	1,205		
8	39	58	234	108	429	158	624	208	819	258	1,014	308	1,209		
9	43	59	238	109	433	159	628	209	823	259	1,018	309	1,213		
10	47	60	242	110	437	160	632	210	827	260	1,022	310	1,216		
11	50	61	245	111	440	161	635	211	830	261	1,025	311	1,220		
12	54	62	249	112	444	162	639	212	834	262	1,029	312	1,224		
13	58	63	253	113	448	163	643	213	838	263	1,033	313	1,228		
14	62	64	257	114	452	164	647	214	842	264	1,037	314	1,232		
15	66	65	261	115	456	165	651	215	846	265	1,041	315	1,236		
16	70	66	265	116	460	166	655	216	850	266	1,045	316	1,240		
17	74	67	269	117	464	167	659	217	854	267	1,049	317	1,244		
18	78	68	273	118	468	168	663	218	858	268	1,053	318	1,248		
19	82	69	277	119	472	169	667	219	862	269	1,057	319	1,252		
20	86	70	281	120	476	170	671	220	866	270	1,061	320	1,255		
21	89	71	284	121	479	171	674	221	869	271	1,064	321	1,259		
22	93	72	288	122	483	172	678	222	873	272	1,068	322	1,263		
23	97	73	292	123	487	173	682	223	877	273	1,072	323	1,267		
24	101	74	296	124	491	174	686	224	881	274	1,076	324	1,271		
25	105	75	300	125	495	175	690	225	885	275	1,080	325	1,275		
26	109	76	304	126	499	176	694	226	889	276	1,084	326	1,279		
27	113	77	308	127	503	177	698	227	893	277	1,088	327	1,283		
28	117	78	312	128	507	178	702	228	897	278	1,092	328	1,287		
29	121	79	316	129	511	179	706	229	901	279	1,096	329	1,291		
30	125	80	320	130	515	180	710	230	905	280	1,099	330	1,294		
31	128	81	323	131	518	181	713	231	908	281	1,103	331	1,298		
32	132	82	327	132	522	182	717	232	912	282	1,107	332	1,302		
33	136	83	331	133	526	183	721	233	916	283	1,111	333	1,306		
34	140	84	335	134	530	184	725	234	920	284	1,115	334	1,310		
35	144	85	339	135	534	185	729	235	924	285	1,119	335	1,314		
36	148	86	343	136	538	186	733	236	928	286	1,123	336	1,318		
37	152	87	347	137	542	187	737	237	932	287	1,127	337	1,322		
38	156	88	351	138	546	188	741	238	936	288	1,131	338	1,326		
39	160	89	355	139	550	189	745	239	940	289	1,135	339	1,330		
40	164	90	359	140	554	190	749	240	944	290	1,138	340	1,333		
41	167	91	362	141	557	191	752	241	947	291	1,142	341	1,337		
42	171	92	366	142	561	192	756	242	951	292	1,146	342	1,341		
43	175	93	370	143	565	193	760	243	955	293	1,150	343	1,345		
44	179	94	374	144	569	194	764	244	959	294	1,154	344	1,349		
45	183	95	378	145	573	195	768	245	963	295	1,158	345	1,353		
46	187	96	382	146	577	196	772	246	967	296	1,162	346	1,357		
47	191	97	386	147	581	197	776	247	971	297	1,166	347	1,361		
48	195	98	390	148	585	198	780	248	975	298	1,170	348	1,365		
49	199	99	394	149	589	199	784	249	979	299	1,174	349	1,369		
50	203	100	398	150	593	200	788	250	983	300	1,177	350	1,372		

Table developed by BioMost, Inc. www.biomost.com bm@biomost.com



USGS Pygmy Current Meter
 Mounted vertically & added
 Rickly Hydrological digital
 Impulse Counter/Timer

TANOMA AERATION



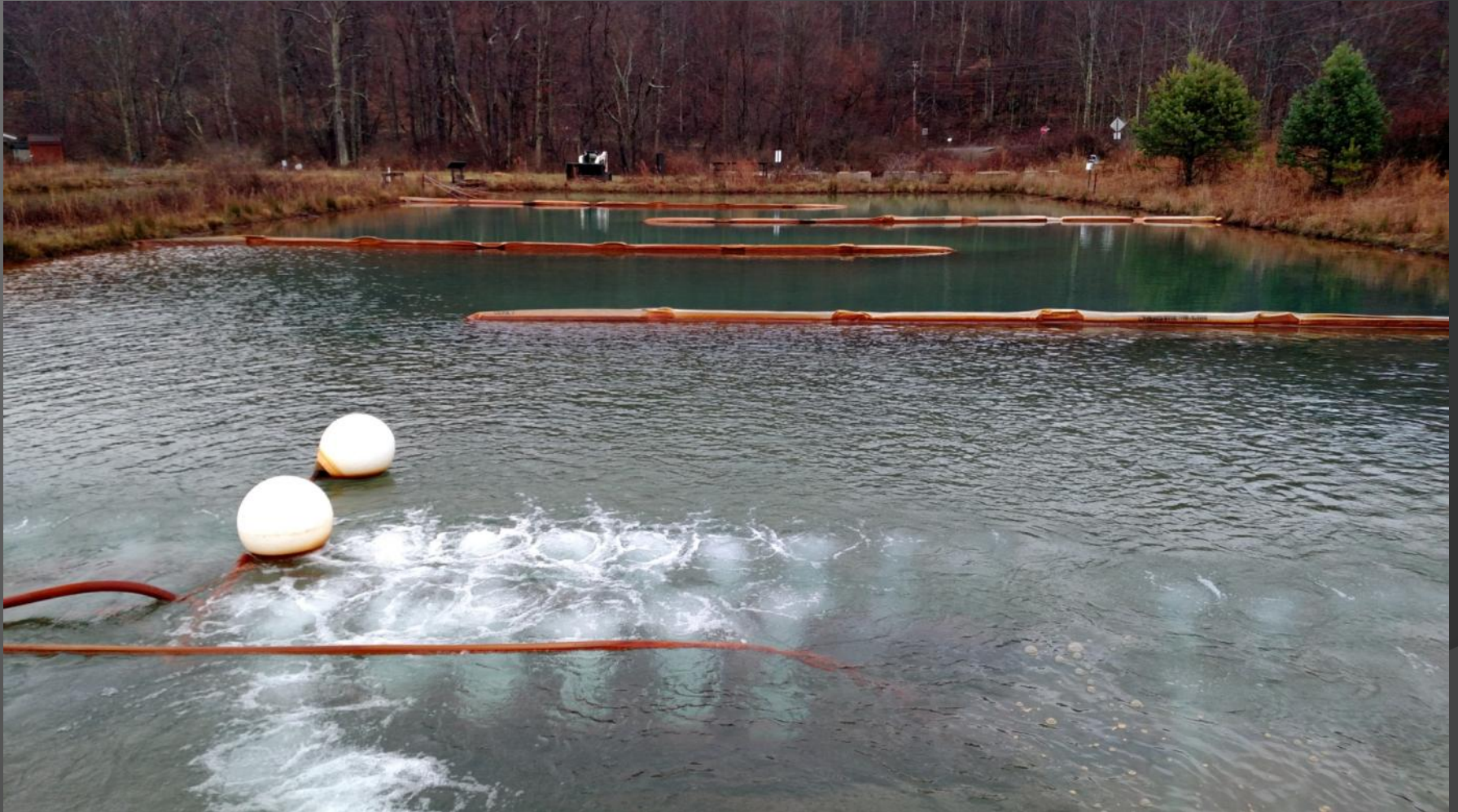
Three 20 12" disk "air sleds" and two 6" x 6' floating air-lifts

TANOMA "AIR SLED"



1.5" SS angle & 1.25" PVC pipe with 12" Fine Bubble Diffusers

TANOMA “AIR SLED”



60 fine-bubble disk diffusers set ~6' deep

TANOMA LIFTERATOR



6" PIPE 6' Long with 6" PVC Float and 4' Aluminum plate

TANOMA LIFTERATOR



Two separate air-lift aerators placed downstream of “air sleds”

AIR PRODUCTION

Site	Flow (GPM)	Air Production (ICFM)	ICFM/100 GPM
Tanoma	4,100	41	1.0
Rock Tunnel	3,400	29	0.9

Sample date: 05/31/2016

Avg. flow (n = 3) & air (n = 18-20) measurements per trompe

THANK YOU!



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