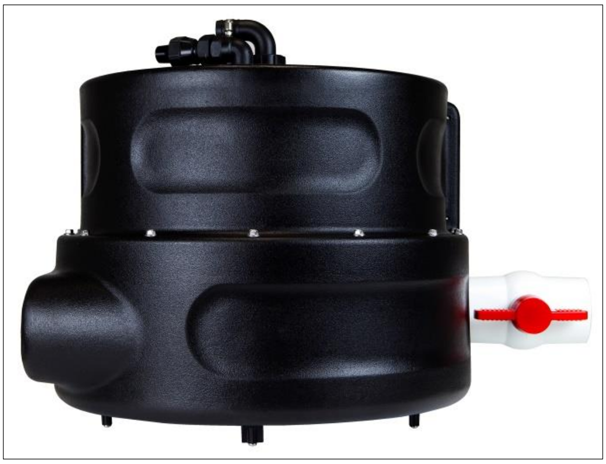
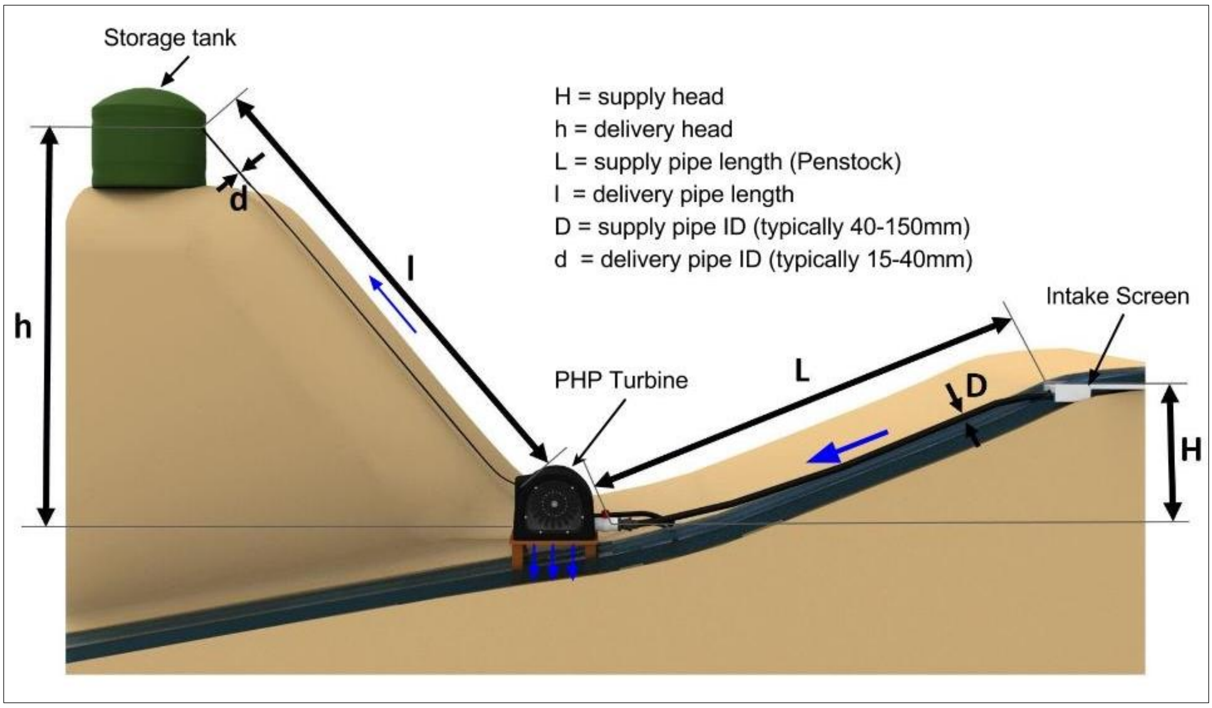
PowerSpout (Pelton Hydraulic Pump) PHP System Design and Installation Manual

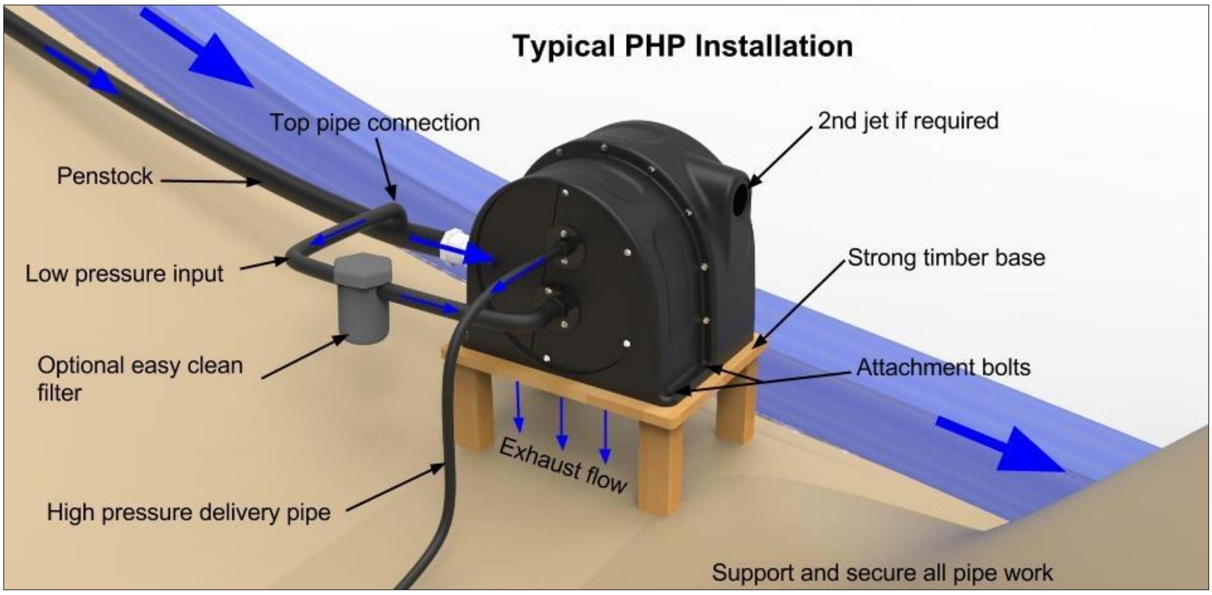




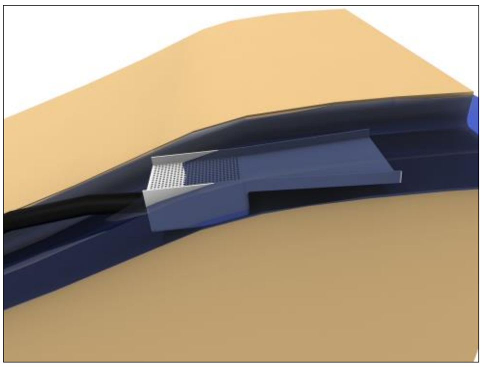


2
3
4
10
7
9
8
5
21
20
18
19
15
22
12
11
17
16
1
6
40
32
33
26
35
36





Please read this manual carefully before beginning installation.



CONTENTS

Notice of Trademark
PowerSpout – is a USA registered Trademark

Notice of Company Registration
EcoInnovation – is a NZ Registered Limited Company

Disclaimer
UNLESS SPECIFICALLY AGREED TO IN WRITING, ECOINNOVATION LIMITED:

(a) MAKES NO WARRANTY AS TO THE ACCURACY, SUFFICIENCY OR SUITABILITY OF ANY TECHNICAL OR OTHER INFORMATION PROVIDED IN ITS MANUAL OR OTHER DOCUMENTATION.

(b) ASSUMES NO RESPONSIBILITY OR LIABILITY FOR LOSS OR DAMAGE, WHETHER DIRECT, INDIRECT, CONSEQUENTIAL OR INCIDENTAL, WHICH MIGHT ARISE OUT OF THE USE OF SUCH INFORMATION. THE USE OF ANY SUCH INFORMATION WILL BE ENTIRELY AT THE USER'S RISK.

Revisions history
1.1. New release July 2015.

PowerSpout Contact details

Web: www.powerspout.com

If you cannot find the answers to your questions about our product, renewable energy systems, or your site's potential in this document or on our website at www.powerspout.com, please visit www.powerspout.com/faq and submit a question. We will answer this as quickly as possible, and you will be notified by email when this occurs.

PowerSpout is a product proudly designed and manufactured by:

EcoInnovation Ltd
671 Kent Road
New Plymouth R.D.1
New Zealand 4371

Web: www.ecoinnovation.co.nz

If you need to contact EcoInnovation by phone then email first via our web site and check the local time in NZ if calling from overseas. Business hours are 9:00am to 5:00pm weekdays only. EcoInnovation is closed for up to 3-4 weeks over the Christmas break from 24th December.

1. Scope of Application and Safety

This document is part of the product.

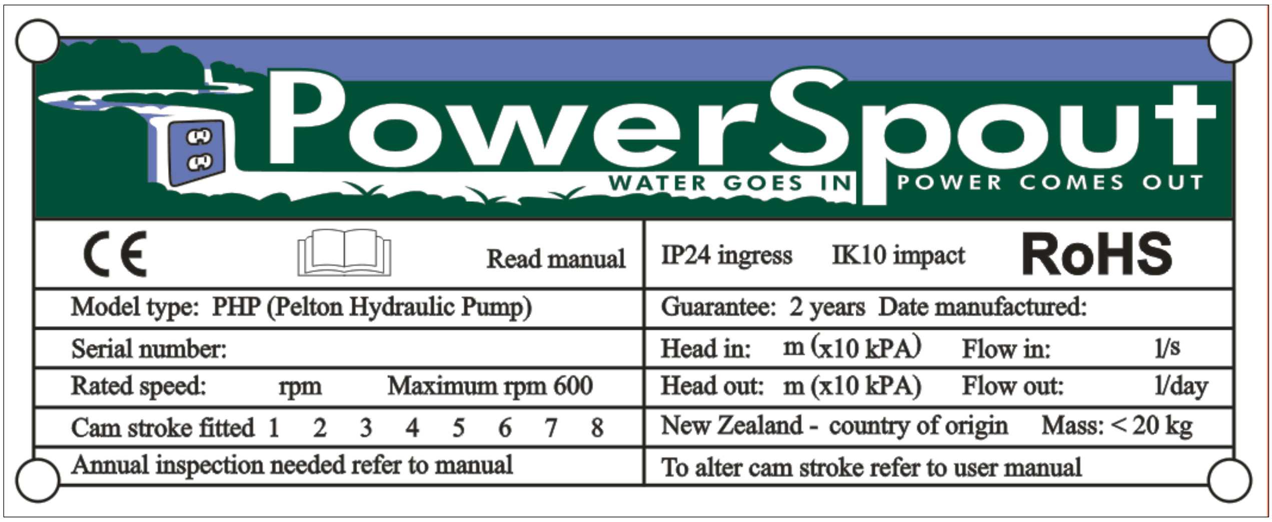
This section addresses safety concerns as required by international standards and accepted best practices.

If you are not technically competent, experienced and qualified you should not install this equipment alone and should engage the services of a suitably trained professional.

Equipment can be installed or operated in such a manner that hazardous conditions can occur; compliance with this manual does not by itself assure a 100% safe installation. If the equipment is properly selected and correctly installed and operated according to this manual, then any such hazards will be minimized.

1.1. Turbine serial numbers

All PHP turbines have identification plates and serial numbers.



For example:
You might see 3678A as the serial number.

This means you have job number 3678. The cam stroke number circled is the cam that is fitted. This is done in pen that can be removed with solvent if you change the cam stroke. “A” means you have more than 1 PHP turbine and they are labelled A, B, C etc.

If you ever need to query an installation or order spares for a product take a picture of the identification plate and forward it with your query. The cam stroke is also engraved on the end of the cam and the end of the shaft, so you can easily identify the cam stroke if it has been changed from that originally supplied.

1.2. Installation checklist

The installation shall be carried out by installers or owners with relevant experience and good practical skills relating to general water reticulation systems.

To meet good working practices and safety requirements for this installation, the installer must:

IN GENERAL

- check for any transit damage to the product prior to installing it, if damaged it must not be installed.
- connect equipment to a high standard to relevant good practices.
- read and comply with this installation manual.

PENSTOCK / SUPPLY PIPELINE

- do not install stop valves at pipe intakes, unless there is an air vent to prevent negative pressure pipe collapse. A stop valve should be fitted at the lower end of the pipe prior to the turbine. A sign at this turbine stop valve to "turn off slowly" may be a good reminder to reduce water hammer effect.
- ensure both the penstock and the supply pipe are of the correct size. Undersized pipes will reduce PHP performance. Use the online calculation tool to select correct pipe sizes.
- do not confuse pipe ID with pipe OD.
- use standard MDPE, HDPE or PVC pipe. It should be verified that penstock and supply can withstand 1.5 times the maximum total pressure to which it is subjected.
- if necessary bury the penstock and supply pipe to protect it against rock falls, tree falls, slips, avalanches, freezing etc.

PLUMBING WORK

- tighten all water connections with appropriate sealing tapes or compounds to ensure connections do not leak.
- provide a suitable disconnection point (such as a Mac union or camlock) close to the turbine so that it can be easily removed for servicing.
- ensure that the installation includes the following: pressure gauge on the penstock (100-200 kPa), a pressure gauge on the delivery pipe (300-2000 kPa), a means of measuring the turbine exhaust flow, a means of measuring the turbine delivery flow. Flow can be simply measured by noting the time to fill a container on known volume.
- Comply with safety advice in this manual when working on high pressure supply pipes.

COMMISSIONING THE PHP TURBINE

- securely fix the turbine base prior to operation.
- if the turbine is likely to be hit by high velocity flood water, build a concrete block deflector wall to offer some protection from such events.
- fill the turbine body with clean vegetable oil up to the top of the clear plastic filler cup, using the bottle supplied.
- do not intentionally run turbine unloaded without the water supply connected.
- do not run turbine at a supply head significantly above the name plate rating.
- in a turbine runaway situation (where the high pressure output pipe bursts) turn off the water supply by closing the water supply valve(s).
- check for excessive noise. There should be very little noise from the pump.
- complete turbine testing and commissioning.
- ensure that all protective fairing/enclosures are in position after commissioning and prior to client hand over.
- complete sensible signage requirements to help the client maintain the pump.
- complete all documentation prior to client hand over.
- make relevant notes in the manuals that will be of assistance to future service personal.
- train the end owner/user of the turbine in routine care and maintenance of the PHP turbine system.

The following safety warning signs are used throughout this manual.

Caution
Cautions identify condition or practices that could result in damage to equipment or personal injury.

1.3. CE and NEMA Declaration

Refer to http://www.powerspout.com for compliance declaration documentations

The PHP pump does not contain any electrical or electronic components.

PowerSpouts products are CE and NEMA compliant for a non-electrical rotating machine.

PowerSpout dealers may request to see the Compliance Folder if required by authorities.

1.4. Standards and certification

All PowerSpout turbines have been evaluated against the relevant sections of major international standards. Refer to http://www.powerspout.com

1.5. Prerequisites

All PowerSpout PHP schemes are assumed to be in the following conditions:

- Run of river (unless advised otherwise).
- Clean river water that will not corrode aluminium parts. Sea water is not permitted.
- Temperate climate. Do not install in situations where the pipe line may freeze or in temperatures below -15°C.
- Terrain that can be walked over safely for pipe laying etc. (i.e. no large vertical drops). The client confirms that the site is unlikely to: slip, have rock falls, flood, earthquake etc. Where such conditions exist the client has taken appropriate measures.
- The client has read manuals, viewed online videos and read installation examples before starting on this project.
- We advise engaging an experienced/qualified installer who has good mechanical and plumbing skills.

Flooding risks:

- On the upstream side the limit is normally the intake screen
- On the downstream side the limit is normally the flooding height that can engulf equipment.

The efficiency and the number of turbines required are determined by the Advanced Calculation tool: http://www.powerspout.com/calculators/
You must submit this data when you place your order for a PowerSpout PHP turbine.

The client must state prior to ordering (see diagram):

- Fall (supply head H) and length of penstock pipe (L).
- Flow available at the intake in summer or the dry season.
- Delivery head (h) and delivery pipe length (l).
- Supply pipe Internal Diameter or bore (D)
- Delivery pipe Internal Diameter or bore (d)
- Flow required per day.

All this information is also contained in the advance calculation tool.

Generally the following are not included for clients outside NZ; these might be provided by a local dealer/supplier/installer:

- Civil works
- Intake screen
- Penstock or delivery pipe
- Water tank
- Installation service

1.6. Fairing safety

The clear glazing on your PowerSpout turbine forms part of a rotating equipment enclosure. There are rotational hazards present. Turbines must be turned off at the valve(s) prior to removing the glazing.

Once the turbine has been commissioned, glazing and rear fairing needs to be fastened in place with the fixings provided.

PHP turbines have quick release toggle latches. The toggle latches are intended for commissioning and jet optimisation. Once this is complete permanent fixings need to be used in addition to the toggle latches. This precaution ensures that children cannot remove the front cover and be exposed to a rotational hazard. The Pelton runner spoons are sharp and could cause serious hand injury.

The turbine installer should ensure that the turbine is mounted such that children cannot reach up under the turbine and be able to touch the spinning rotor.

1.7. Pressurised water pipes

Legislation covering pressurised pipes applies in most countries for pipe pressures over 10 Bar. The PowerSpout PHP runs at less than 10 Bar in many applications, but not all. It is capable of pumping to 20+ Bar. Check with your local authority if you have any legal requirement that may concern this installation in your country.

Generally there is little risk at less than 10 Bar pressure. The biggest risk is insecurely fastened pipe joiners that blow off, with the free end of the pipe hitting people. Securing the pipe at regular intervals, particularly near the joins, and checking all joiners are tight will eliminate such risks.

Ensure you install pipe with the correct pressure rating.

2. Step by step design overview

This section briefly outlines the main choices you will need to make in the design of your system and ordering the delivery.

2.1. Survey your site

Section 4 describes how to measure the head and flow of your site. You will also require the length for the "penstock" called the supply pipe. This is the pipe between the intake and the turbine site. Finally you need the length and head of your delivery pipe. Take this information to the online Advanced Calculator or to a dealer. You will learn how much flow to expect from the PHP turbine to your water storage. Once you have decided the best layout you may need to get permissions, and take more accurate measurements before proceeding.

2.2. Using surplus water

PHP turbines may pump a lot of water at times when you do not need it. This will cause your tank to overflow. Ensure that this overflowing water does not cause erosion and can get back to the stream cleanly.

We do not advise that you fit a ball cock in the storage tank and pressure relief valve at the PHP turbine. We advise that if you are pumping much more water than you need, then you simple fit a smaller jet (and cam stroke if required) so that you pump what you need.

2.3. Optional extras you may wish to order

Check the pricelist for additional items that you may wish to have shipped with your PHP turbine at no extra shipping cost in many cases. The list includes some useful spare parts.

2.3.1. Bearings and oil lubrication

Bearings are inexpensive and easy to replace. See "PowerSpout PHP how to assemble". We recommend you hold a spare set of bearings and a seal kit and 4 one-ways valves (one full set of spare seals is supplied with every pump) on the shelf. Many customers order spares with their turbines to ensure quick replacement and minimum downtime.

NOTE: As the bearings run in oil they will last many, many years. You will need to change the oil after the initial running in period of 1 month from new, and then every year. We advise vegetable oil (as this does not harm the stream environment if you ever get an oil leak) but such oil is prone to evaporation and will need to be topped up every 3-4 months. This is very easy and will only take a few minutes to do. An annual bearing inspection is also required. Check bearing health by noting if there is any play on the cam shaft or the Pelton rotor.

2.3.2. Manifold fittings

The PHP turbine requires pipework and fittings to connect it to your main pipeline or "penstock" (see section 4.9). You can buy these items from PowerSpout or locally. Most PHP turbines run on 1 jet and for these it is a relatively easy matter to connect your penstock via a reducer and mac union to the 2" Valve of your PHP turbine. If you need a 2 jet PVC manifold with mac union and a pipe fitting to suit your penstock OD, then PowerSpout can normally supply this if required.

The PLT turbine comes with a valve and pressure gauge. An upgrade to twin jets is available for a small fee.

Camlocks fittings for easy connection via a 50mm (2”) flexible hose are available as an upgrade.
It's worth checking the pricelist to see what can be delivered directly and save effort. There may be additional shipping costs for manifold fittings that depend on your location.

2.3.3. Spare jets

Each PHP turbine is supplied with jets cut to the size that was calculated to your design in the Advanced Calculator. If your original measurements were accurate then these will work well, you can also close valves to adjust the flow. You will also get four spare jets that you can cut to any size (see Section 6.22)

More spare jets can be ordered with the turbine to save on carriage costs later if you think you might need them.

3. Renewable energy from a PowerSpout PHP turbine

Congratulations on your choice of a PowerSpout PHP turbine. This ingenious little device will give you years of trouble free water pumping, avoiding the need for more expensive alternative solutions. Not only does the PowerSpout PHP give you renewable energy, it is also made from a high % of recycled materials, making it one of the most eco-friendly micro-hydro pumps available on the global market.

PowerSpout PHP turbines commonly achieve 40-50% efficiency (at input powers over 200W) over a very wide range of pumping heads, which is superior to water rams that many readers will be familiar with. For a list a PHP turbine advantages relative to conventional water rams refer to click here.

You will see that our calculations take into account penstock and supply pipe losses, so we will not fall into the common trap of overstating output. Many installations exceed our flow predictions as we use a conservative calculation model.

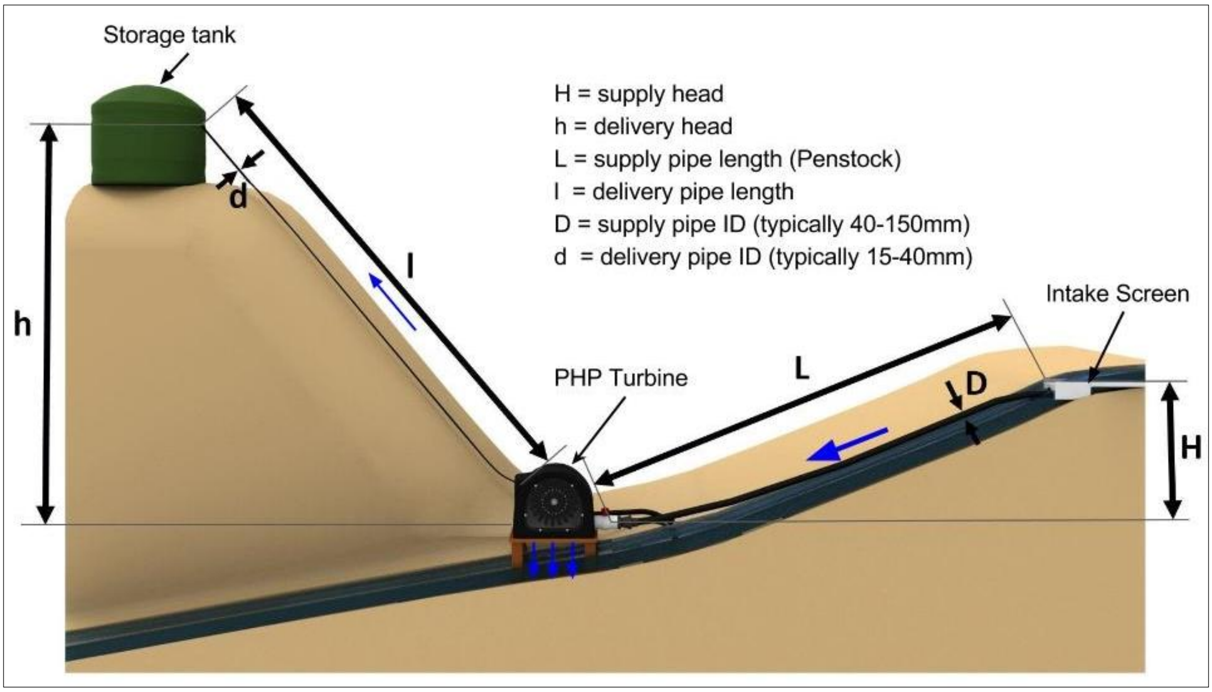
The manual is intended to guide you through PowerSpout PHP selection, design, and the installation process. All PowerSpout PHP turbines are shipped fully assembled with only the jet holders removed. This has been made possible due to an improved freight arrangement with DHL. The installer is advised to familiarise themselves with the turbine assembly prior to installation. See the "PowerSpout PHP how to assemble" for details of how to replace the cam and bearings.

Videos to introduce PowerSpout PHP turbines are available via www.powerspout.com. Please note that video clips do become outdated quickly and may not be updated. Where instructions differ, the latest written manual (available online) will always be the correct method to follow.

3.1. How high can the PowerSpout PHP pump water?

The PowerSpout PHP has a maximum delivery (pumping) head rating of 200 m (650 feet).

A delivery head higher than 200 m (in some cases up to 250 m) can be successfully implemented but with reduced lifespan and warranty on the PHP turbine. Seek our advice on delivery head above 200m.



3.2. How much water will the PowerSpout PHP pump?

3.2.1. Head and Flow

The pumping capacity of your site is determined by the water supply, primarily by the vertical distance the water falls (head) and how much water flows in a given time (flow rate). These site characteristics can be easily measured with basic tools such as a bucket and a level. See next section for more.

Flow changes throughout the year and you will need to be realistic about how this impacts on the output. A solar PV powered pump is a very good choice in dry locations. PowerSpout are working on PV solar hydraulic pump (SHP) and we hope to have our solution ready for retail sale in late 2016.

For the PHP turbine the head is measured between intake water level and the turbine jets below. Water exits the turbine at atmospheric pressure back into the stream.

3.2.2. Estimating the pumping potential

A rough estimate of your pumping potential can be calculated as follows:

- Litres per day pumped
  = [36,000 x Penstock "supply" head (m) x Penstock flow (l/s)] / delivery head (m)

A more accurate answer can be obtained from our online PHP calculation tool.

If you have surplus intake water available, and large enough pipes for more flow, and one standard PowerSpout PHP turbine cannot pump sufficient water to meet your needs then you can add a 2nd or 3rd connected to the same penstock and supply pipe.

3.2.3. Worked example

For example a site with:

- 8 litres/second flow rate
- 6m vertical fall of the penstock (supply head)
- 200m lift to water tank (delivery head)

Litres per day pumped = 36,000 x 6 x 8 / 200 = 8640 l/day

3.3. How to match the constant flow supply to our changing demands?

The solution is to store water in a header tank. When you need more water than the PHP turbine can supply, you can then draw the extra from the tank.

3.4. What happens if there is not enough water for the turbine?

The flow of water through the PHP turbine depends on the head of pressure and on the size and number of jets that direct the water onto the Pelton runner. If there is not enough water entering the penstock at the intake to keep this flow supplied then air will enter and the pipe will gradually empty. This reduces the head and consequently the flow in the jets is reduced and an equilibrium is found. However, this will not produce the best pump flow output, due to reduced head. If the flow output is observed to decline (or the PHP turbine stalls) then the **user should intervene** and adjust the turbine jets to match the new flow. Closing one of the turbine's valves may be enough to reduce the demand enough that the penstock refills and full pressure is restored. Flow output will be less than full flow but at least with a full pipe the best use is being made of the available water. If the turbine stalls when a smaller jet is used, then you will need to install a new cam shaft that has less stroke than the one installed.

Changing of the cam is described in the "PowerSpout PHP how to assemble" document.

The user should check the penstock pressure gauge which will drop if air enters the penstock. Make sure that the penstock is always full by adjusting the number and size of jets in use. If the pressure is low then it may be a good idea to close all the valves and wait until the pipe refills before opening a reduced number of jets or changing to smaller jets to match the prevailing flow conditions.

On a good site this adjustment may rarely if ever be needed as there will always be sufficient flow of water to pump at full flow. But where necessary the PowerSpout PHP can make good use of partial flows provided that the jets and cam stroke are adjusted to suit.

3.5. How can we be sure of getting the pumping head out of the PHP turbine?

Your turbine will have been optimised to produce maximum flow under the conditions specified by the input data you provided. Turbine head depends on the cam stroke. The design process involves predicting the best rotational speed for the turbine, which depends in turn on the height of the water tank, and the supply head and the flow data you measured.

Accurately measure the head at your site and the height of your tank above the turbine, and use the recommended pipe sizes, so that the actual pressure of the water ends up being close to the value that the turbine and pump are designed for. Every site is different, so the design process is critical, and the measurement of head is key.

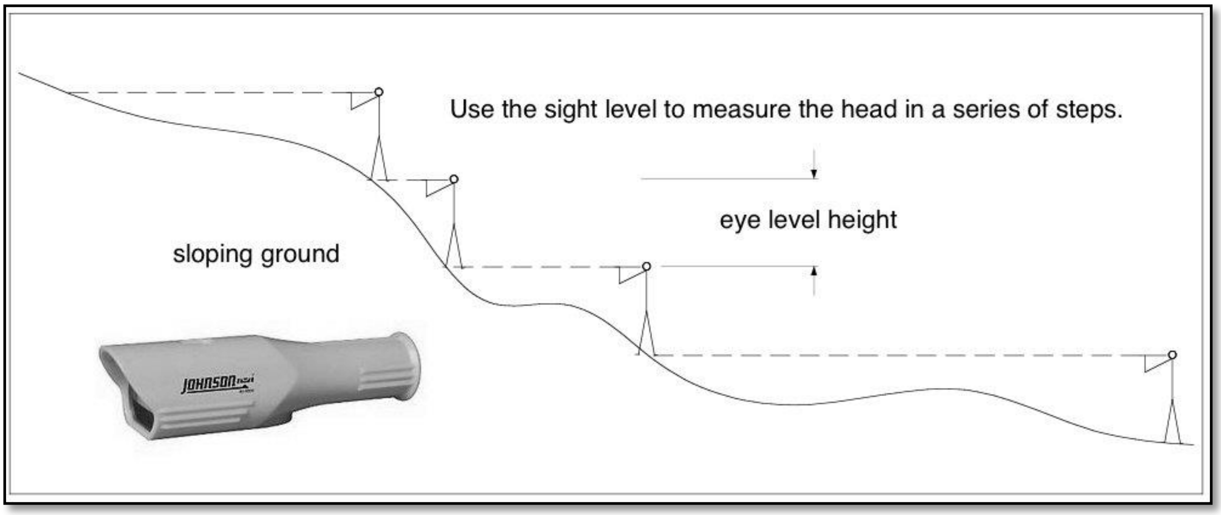
However, if you get your site data wrong, the PHP pump can always be made to work by adjusting the jet size and cam stroke. These are both easy to do. You may need to obtain another cam from PowerSpout or have one made locally. Changing of the cam is described in the "PowerSpout PHP how to assemble" document.

4. Designing your site layout and choosing your PHP turbine stroke and jet size

4.1. Measuring Head

You will need to measure the vertical drop in feet or meters (referred to as head or fall). A map with contours can be useful for initial feasibility study followed by a site survey using the methods below. It's a good idea to use more than one approach, so you can check accuracy.

Builder's optical level ("sight level") - measure the fall between intake and turbine in steps as you progress along the pipe route. This is good for lower falls and it is very accurate. You can use the height of the spotter's eye level as a unit of measure and move up the slope in a series of equal steps. Use a helper to mark the spot, or simply keep your eye on that spot until you are standing on it ready to sight the next one.



Low cost laser level - at dusk or in low light conditions project a horizontal beam and using a long staff measure the vertical drop, as you progress down alongside the stream. You may have to repeat this at a few locations.

Pressure gauge - lay a length of small bore plastic pipe or hose, fix a pressure gauge to the end and measure the pressure of the water with the pipe full. 14.5 psi is 33 feet of fall (100 kPa is 10m of fall). Make sure you clear the line of all air first. This is an accurate method and easy to do.

Click here for a recent Home Power article on how to measure the head.

4.2. Measuring Flow

Try and find a place in the stream where it drops quickly over a rock, place your bucket below and measure the time to fill it.

Use the largest possible bucket you can find as the longer it takes to fill the more accurate your reading will be.

For flows greater than 10 litres/second try to estimate your flow using a larger bucket in the river and measure at various places across the river. It will not be as accurate but at higher flows it is not that critical.

A "notched weir" is useful for monitoring flow over time as it can be used to take quick readings on a regular basis, but it takes some effort to construct.

Click here for a recent Home Power article on how to measure flow rate.

IMPORTANT: "Gallons," "gals," and "gpm" refer to the US Imperial Gallon (3.8 litres), as opposed to the UK Imperial Gallon. (See section 10 for units and conversions.)

4.3. Choosing the correct number of PHP turbines for your site

Different sites will need a different number PowerSpout PHP turbines depending on the head and flow. The online calculation tool can determine for you the number you need to install, which depends on your water resource potential and the amount of water you wish to pump.

Version	Penstock Head (m)	Penstock Flow (l/s)	photo
PowerSpout PHP	2 – 12 m	1 – 8 l/s per PHP installed	

When you have found out the head and flow rate at your site, the tables on the next page will quickly tell you the flow you can deliver to your tank (assuming no pipe losses). For a more accurate result you need to use the online calculation tool.

All output flows are estimates based on real world test data. Refer to our warranty and disclaimer terms.

Flow in litres/day at 1 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	15032	11450	9217	7704	6622	5799	5152	4646	3713	3099	2653	2324
36	11.0	13833	10515	8468	7066	6065	5318	4715	4259	3408	2837	2435	2131
33	10.0	12636	9576	7696	6435	5522	4835	4302	3872	3098	2582	2279	1935
30	9.0	11426	8633	6950	5802	4978	4360	3876	3489	2792	2327	1990	1745
26	8.0	10189	7704	6182	5160	4429	3876	3446	3102	2482	2063	1773	1551
23	7.0	8921	6750	5401	4509	3875	3392	3015	2708	2172	1805	1551	1354
20	6.0	7685	5779	4647	3865	3322	2900	2585	2326	1857	1548	1330	1164
16	5.0	6420	4833	3864	3222	2769	2423	2154	1939	1551	1290	1108	970
13	4.0	5159	3881	3107	2590	2220	1943	1727	1555	1244	1032	888	777
10	3.0	3879	2898	2330	1942	1665	1457	1289	1166	933	777	666	0
7	2.0	2574	1951	1546	1301	1115	976	867	781	625	521	0	0

Flow in litres/day at 2 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	30853	23168	18561	15473	13258	11602	10320	9289	7431	6193	5305	4645
36	11.0	28287	21254	17005	14176	12153	10641	9459	8509	6812	5673	4866	4255
33	10.0	25727	19325	15460	12895	11054	9668	8599	7740	6192	5160	4423	3870
30	9.0	23177	17385	13931	11598	9943	8711	7744	6969	5576	4646	3983	3485
26	8.0	20609	15473	12383	10322	8838	7743	6883	6195	4956	4125	3540	3097
23	7.0	18038	13523	10822	9031	7742	6766	6014	5419	4336	3613	3097	2710
20	6.0	15464	11605	9288	7740	6627	5798	5160	4644	3716	3093	2654	2322
16	5.0	12872	9670	7738	6441	5521	4831	4299	3869	3096	2580	2211	1935
13	4.0	10321	7744	6181	5163	4427	3873	3442	3098	2479	2065	1770	1549
10	3.0	7739	5805	4644	3861	3309	2903	2580	2322	1858	1544	1327	1161
7	2.0	5142	3869	3097	2581	2213	1937	1722	1550	1234	1033	886	771

Flow in litres/day at 3 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	46047	34662	27792	23178	19875	17395	15465	13919	11137	9282	7951	6962
36	11.0	42252	31786	25480	21247	18219	15945	14175	12758	10208	8507	7292	6381
33	10.0	38444	28923	23166	19316	16562	14494	12885	11597	9279	7733	6624	5800
30	9.0	34626	26022	20851	17373	14904	13043	11595	10436	8350	6958	5964	5216
26	8.0	30799	23134	18534	15451	13246	11592	10305	9275	7416	6184	5300	4638
23	7.0	26963	20256	16215	13517	11588	10140	9015	8113	6486	5409	4636	4057
20	6.0	23104	17372	13904	11576	9935	8694	7729	6956	5565	4637	3975	3478
16	5.0	19279	14473	11568	9654	8276	7241	6429	5793	4635	3858	3311	2897
13	4.0	15419	11571	9260	7717	6615	5788	5145	4631	3705	3084	2646	2316
10	3.0	11567	8659	6944	5776	4961	4341	3858	3473	2778	2315	1984	1736
7	2.0	7693	5757	4606	3848	3298	2886	2656	2309	1842	1539	1319	1154

Flow in litres/day at 4 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	47714	46442	37615	30971	26546	23221	20647	18582	14866	12388	10618	9291
36	11.0	45678	42584	34067	28381	24326	21292	18926	17034	13623	11352	9733	8517
33	10.0	43566	38700	30970	25808	22121	19350	17205	15480	12384	10323	8848	7742
30	9.0	41296	34830	27880	23234	19915	17425	15489	13940	11152	9232	7966	6970
26	8.0	38962	30977	24782	20561	17701	15489	13768	12391	9913	8261	7081	6196
23	7.0	36116	27104	21670	18059	15488	14544	12039	10842	8673	7228	6192	5418
20	6.0	30974	23217	18585	15478	13275	11616	10319	9273	7434	6195	5310	4646
16	5.0	25810	19358	15477	12906	11062	9679	8604	9679	6195	5162	4425	3872
13	4.0	20659	15476	12396	10317	8854	7747	6887	6190	4958	4132	3542	3099
10	3.0	15492	11619	9295	7746	6640	5803	5158	4648	3718	3098	2656	2324
7	2.0	10338	7753	6203	5169	4430	3877	3446	3101	2481	2068	1772	1551

Flow in litres/day at 5 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	47728	47295	46452	38710	33170	29024	25807	23226	18581	15484	13272	11613
36	11.0	45664	45327	42580	35483	30405	26613	23648	21290	17032	14189	12166	10645
33	10.0	43554	43190	38708	32257	27649	24193	21498	19348	15483	12903	11059	9677
30	9.0	41296	40995	34836	29022	24883	21773	19354	17418	13935	11609	9953	8709
26	8.0	38924	38618	30964	25796	22117	19353	17202	15482	12386	10321	8847	7741
23	7.0	36439	33855	27101	22584	19358	16938	15056	13550	10834	9034	7743	6775
20	6.0	33726	29035	23214	19356	16591	14517	12904	11614	9291	7743	6636	5807
16	5.0	30792	24193	19355	16129	13816	12089	10753	9677	7742	6448	5530	4839
13	4.0	24803	19352	15482	12901	11058	9676	8601	7741	6189	5161	4421	3870
10	3.0	19336	14519	11616	9680	8297	7251	6445	5808	4646	3872	3319	2904
7	2.0	12900	9675	7740	6450	5529	4838	4295	3870	3096	2580	2211	1935

Flow in litres/day at 6 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	47714	47363	46923	46447	39812	34835	30965	27868	22295	18579	15825	13934
36	11.0	45677	45286	44994	42575	36493	31932	28384	25545	20436	17030	14597	12773
33	10.0	43566	43209	42909	38704	33174	29019	25802	23222	18578	15481	13270	11611
30	9.0	42319	41029	40656	34821	29847	26124	23214	20899	16714	13933	11942	10450
26	8.0	38965	38645	37152	30960	26537	23213	20640	18570	14856	12380	10615	9288
23	7.0	36421	36181	32505	27088	23211	20316	18059	16248	12998	10835	9285	8126
20	6.0	33736	33475	27868	23223	19905	17417	15482	13295	11147	9289	7962	6967
16	5.0	30754	29025	23220	19350	16586	14512	12900	11610	9288	7740	6634	5805
13	4.0	27513	23215	18572	15468	13258	11608	10318	9286	7429	6191	5303	4643
10	3.0	23222	17416	13933	11611	9952	8708	7741	6967	5573	4644	3981	3483
7	2.0	13144	9870	7896	6580	5633	4935	4386	3948	3158	2632	2256	1974

Flow in litres/day at 7 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	47652	47317	46996	46554	45254	40631	26116	32500	26004	21666	18574	16252
36	11.0	45691	45338	44941	44625	42564	37243	33105	29795	23836	19863	17025	14897
33	10.0	43565	43199	42864	42505	38686	33851	30099	27089	21671	18059	15749	13544
30	9.0	41296	40961	40670	40393	34826	30473	27087	24378	19503	16252	13930	12189
26	8.0	38965	38618	38348	36103	30954	27085	24076	21668	17334	14445	12382	10831
23	7.0	36439	36123	35845	31596	27082	23697	21064	18958	15166	12638	10833	9479
20	6.0	33751	33458	32495	27079	23211	20303	18047	16247	12998	10832	9284	8121
16	5.0	30785	30553	27082	22569	19345	16926	15046	13533	10833	9027	7738	6771
13	4.0	27513	27059	21660	18050	15462	13538	12026	10824	8664	7216	6185	5415
10	3.0	23856	18132	14505	12088	10348	9066	8058	7253	5795	4835	4144	3526
7	2.0	13144	9870	7896	6580	5633	4935	4386	3948	3158	2632	2256	1974

Flow in litres/day at 8 l/s input flow

Delivery head feet		98	131	164	197	230	262	295	328	410	492	574	656
Supply head		Delivery Head in m											
ft	m	30	40	50	60	70	80	90	100	125	150	175	200
39	12.0	47654	47363	46960	46554	46221		41270	37143	29710	24758	21225	18569
36	11.0	45678	45327	44974	44570	44272	42557	37829	34046	27233	22694	19455	17020
33	10.0	43566	43158	42866	42530	42229	38686	34388	30944	24759	20633	17685	15474
30	9.0	41296	40961	40656	40359	39794	34809	30951	27856	22285	18571	15918	13928
26	8.0	38965	38645	38312	38034	35369	30948	27509	24758	19807	16506	14148	12379
23	7.0	36421	36128	35887	35609	30935	27076	24068	21654	17324	14436	12378	10830
20	6.0	33736	33475	33219	30939	25519	23197	20626	18563	14851	12376	10608	9282
16	5.0	30797	30534	30320	25777	22088	19322	17184	15461	12373	10311	8838	7733
13	4.0	27517	27301	22306	18588	15933	13949	12392	11153	8928	7440	6373	5576
10	3.0	23856	18132	14505	12088	10348	9066	8058	7253	5795	4835	4144	3526
7	2.0	13144	9870	7896	6580	5633	4935	4386	3948	3158	2632	2256	1974

A black box indicates that two or more pumps may be required. The jets size, pump power or exhaust flow limit has been reached for 1 pump.

For flows higher than listed in the above table more than 1 PHP turbine will be required.

The Advanced Calculation Tools at www.powerspout.com can perform accurate site calculations. The Advanced Calculator will help you find the best sizes of pipe and cable for the site, and predict the net power output for each possible size that you might choose.

4.4. Siting your PowerSpout PHP turbine

Some tips for locating a good site for your turbine include:

4.4.1. Choose a place that is accessible.

If necessary make steps and put in rope handrails to ensure that your PHP turbine can be accessed safely.

4.4.2. Choose a site that has the most fall

You should position the PowerSpout to obtain the greatest fall (head of supply pressure) possible with the shortest length of Penstock pipe.

4.4.3. Keep your PHP turbine as low as possible

Maximise the head, but do ensure that it is above maximum river flood level.
Your PHP turbine should also be positioned at least 50-100 mm above ground height to allow exhaust water to escape. Choose a site where the exhaust water can be returned back to the river cleanly.

4.4.4. Place it as close to your water storage tank as possible

The cost of the pipe is important. The distance between your PHP turbine and the tank has a significant bearing upon the supply pipe size required. As PHP pumps run 24/7 the supply pipe required is much smaller in diameter than would be required for a solar PV or grid powered pump running intermittently to meet the same needs.

Adding a PowerSpout PHP to your property can often eliminate the need for a higher cost alternative solution.

4.4.5. PHP turbines do make some noise - but not much.

You are unlikely to be able to hear a PHP turbine at 20m away. So noise is not an issue. For what little noise there is, vegetation around the PHP turbine will dramatically reduce the distance that noise carries.

Refer to section 17 for typical noise measurements.

This is not the case for most water rams which are very noisy. Some of the larger models can be heard over 1000m away, and this generally upsets your neighbours.

4.5. Connecting two small streams into one PHP PowerSpout

We are often asked if two small streams can be piped into a common turbine. This is not recommended, unless the head and pipe friction losses for each pipe are very similar. Generally we would advise two turbines, one for each site. The output of both could then be joined together into a supply pipe.

4.6. PowerSpout PHP site data requirements

In order to assess your site pumping potential you can either

- Visit our web site www.powerspout.com and complete the advanced calculator, or
- Complete the table below and email it to questions@powerspout.com we will reply promptly with the best hydro option available for your site.

Your PHP turbine will be designed for the site data you supply above. **If you operate it on a different site, the output flow will differ and not necessarily match the prediction of the advanced calculator**. A new cam stroke and jet size may be required to obtain the best results in such cases. If you intend to run your turbine over a wide range of flow rates, you need to state this at the time of ordering.

Hydro site data required for PowerSpout PHP product manufacture

Question	Units	
PowerSpout turbine type	PHP	
Have you read the PowerSpout PHP product manuals? You must do so before placing an order	Yes/No	
Head at site (vertical drop/fall of supply pipe)		m or ft
Penstock (supply pipe) length required to get fall		m or ft
Penstock pipe inside diameter if installed		mm or inch
Do you want us to advise your penstock pipe size?	Yes / No	-
Flow available at intake in dry season		l/sec or gal/min
What is the delivery pipe length from PHP turbine to the water tank?		m or ft
If delivery pipe is installed, what size is it?		mm^2 or sq inches
Do you want us to advise delivery pipe size?	Yes / No	-
How much water do you require to be pumped to your tank each day?		litres/day or gal/day
Do you want 2" (50mm) BSP or NPT thread in your valve connection	BSP/NPT	

4.7. The Penstock (and the delivery pipe)

The online advanced calculator at www.powerspout.com/calculators/ will have advised the appropriate internal diameter (ID) of pipe for the "penstock" or supply pipeline, based on the site data you entered. You should position the PowerSpout PHP to obtain the greatest fall possible in the shortest distance.

For initial feasibility you can use a map and/or gps to survey penstock options. When you have chosen the locations for the intake and the turbine, measure the pipe length using a long tape or wheel, be accurate, as this information will be required to buy the pipe and it's important to get it right.

Try to lay the pipe to avoid high spots in the line that might trap air bubbles. Use a level to check that it is always graded downward. If a high spot is unavoidable you will need to place a bleed valve at the highest point in the pipeline to purge air. Air locks in the line will

significantly affect the output of the PHP turbine. The longer the penstock the more of a problem this tends to be. Penstocks for PHP turbines are normally in the 50-200m range.
If there are many high spots trapping air then automatic bleed valves may be useful in such cases.

4.7.1. Pipe sizes

Pipe sizes commonly used with our PHP turbine product include:

- PVC for larger sizes based on OD (110-300 mm normally)
- MDPE or HDPE based on OD (50-110 mm normally)
- LDPE based on ID in NZ/AUS (15-50 mm normally)

Many different standards exist for pipe sizes which vary depending on industry and geographical area. The pipe size designation normally includes two numbers - one that indicates the outside diameter (OD) and the other that indicates the wall thickness. American pipes were categorized by inside diameter (ID) in the past but this was abandoned to improve compatibility with pipe fittings and joiners that usually fit the OD of the pipe.

Inside diameter is critical for calculation of pipe friction loss since a variation of as little as 1 mm can have a very significant effect on the output flow of the PHP turbine. Take care with which diameter you are referring to since if calculations are done based on pipe ID and the pipe is then purchased based on OD your turbine deliver less flow than predicted due to increased pipe friction. Pipes below 40 mm ID cannot normally be used for Penstocks as friction losses are too high. Pipes below 15 mm ID cannot normally be used for long delivery pipes to an elevated water tank as friction losses are too high.

Pipes have different pressure ratings, so a given pipe size is often available in a number of pressure ratings. Penstocks are unlikely to be over 12m fall, so pressure rating is not an issues on the supply side and so low grade pipe can be used.

In NZ for example, polyethylene (PE) pipes can be purchased from 35 m (50 psi) head rating to 160 m (230 psi) head rating. Some sizes are based on ID and some on OD sizing, so be careful and double check with your supplier the OD and ID of the pipe. Higher pressure pipes have thicker walls and smaller ID.

4.7.2. Delivery pipe material

A delivery pipe from pump to storage tank should be:

- Equal to or larger than recommended from the calculations for the specified input and calculated output flow of your PHP turbine.
- Cost effective, tough and durable for 20-50 years.
- Able to handle the static pressure of the head of water to the tank.
- Easy to lay and bend around obstacles.
- Able to be purchased in long lengths.

The PowerSpout PHP has a maximum delivery head rating of 200m (in some cases up to 250m). HDPE pipe is commonly available to 160 m static head. Above 160m head seek advice from your pipe supplier on what options they can offer. PVC pipes can go up to 250m head.

A water head >200m can be successfully implemented but with reduced lifespan and warranty on the PHP turbine. Seek our advice on head above 200m.

4.7.3. LDPE, MDPE and HDPE pipes

The range and the fact that they are durable, low cost and commonly available in a wide range of sizes, pressure ratings and lengths makes PE pipes the obvious choice for the PowerSpout PHP turbines penstocks and supply pipes.

Remember that you can vary the pipe pressure rating to minimise costs. For example, if you have a 160m delivery head you start with high grade (16 bar) pipe, a length of 12 bar, then 9 bar and finally 6 bar. Laying 16 bar pipe all the way can almost double the cost of the pipeline. If you do this the pipe ID may change, so the calculated output may not be correct. To avoid disappointment use the smallest pipe ID in the online calculator and your PHP turbine will pump a little more than predicted.

Table 1. Pipes common in NZ [(Rural Direct)]

Pipe OD mm	Pipe ID mm	Material	Pressure rating PSI	Pressure rating M	Pressure rating kPa	Pressure rating Bar
17	**15**	LDPE	130	90	900	9
25	**20**	LDPE	116	80	800	8
25	**22**	MDPE	130	90	900	9
25	**21**	MDPE	180	125	1250	12.5
32	**25**	LDPE	94	65	650	6.5
32	**28**	MDPE	130	90	900	9
32	**27**	MDPE	180	125	1250	12.5
38	**32**	LDPE	72	50	500	5
40	**35**	MDPE	130	90	900	9
40	**34**	MDPE	180	125	1250	12.5
44	**40**	LDPE	65	45	450	4.5
50	**44**	MDPE	130	90	900	9
50	**42**	MDPE	180	125	1250	12.5
57	**50**	LDPE	50	35	350	3.5
63	53	HDPE	131	90	900	9
63	50	HDPE	174	120	1200	12
75	65	HDPE	116	80	800	8
90	79	HDPE	116	80	800	8
110	94	HDPE	116	80	800	8

Bold indicates the change from ID to OD sizing

The above table will assist you entering available pipe ID sizes in the online calculation tool.

4.7.4. PVC penstock pipes

PVC pipes are widely used in applications ranging from low cost road culverts to mains pressure water distribution networks in cities. PVC pipe sizes vary around the world (see Annex II: Common PVC pipe sizes) and frequently the available pipe sizes differ between countries. Most countries seem to either use the American or British pipe size dimensions, or develop their own standards for pipe sizes.

PVC pipes are often more cost effective than PE pipes in sizes above 110 mm. As PVC pipes glue together the cost to join them is low, so short lengths can be used (normally 4-6 m). They can be bent in-situ by applying heat to the tension side of the bend. We therefore see them mainly used at lower head sites where high water flow is available and often on sites running multiple PHP turbines from a common Penstock and supply pipe.

PVC is not as durable as PE and can be shattered by falling rocks and trees. Where these risks can be managed and the price is right for the application they are commonly used. PVC left in direct sunlight will weaken and become brittle with age.

PVC culvert grade farm pipes glued together are the lowest cost PVC pipe you can obtain and are very suitable as a penstock for PHP turbines.

4.7.5. Pipe myths

We often get told that the pipe has to reduce in size in order to keep up the pressure. This is a huge misconception and arises from confusion with irrigation schemes. If you decrease the pipe size you increase the friction, which will actually decrease the final pressure.

The pipe for an irrigation scheme supplying many farms will reduce in size as the last farm has to convey a smaller amount of water. The start of the pipe has to be larger because it has to convey the water needed for all the farms on the line. The pipe myth arises because pictures of irrigation schemes have often been incorrectly used to depict hydro schemes.

People also confuse pressure with velocity; if you increase the pipe velocity by reducing pipe size the pressure at the turbine will decrease. Reducing pipe size increases water velocity, which increases pipe friction and reduces even further the pressure in the pipe, resulting in less pumped water.

If the penstock simply discharges "full bore" (for example, to flush out sediment) then the flow will be large, and there will be no pressure left. Pressure is all used up in pipe friction. Normally the PHP turbine uses jets to restrict the flow and convert the pressure into velocity to drive the Pelton runner. The flow in the penstock will be controlled by the size(s) of jet(s) that you use in your PHP turbine(s). Larger jets will demand more flow, which will in turn create more friction loss, and may reduce the pressure at the turbine. Smaller jets will minimise the flow and the pressure will be slightly higher. Using a small bore **jet** may result in higher pressure (due to lower flow rate) but using a smaller bore **pipe** will not, as it simply increases the friction.

Another common myth is that pipe bends are the cause of a lot of penstock losses. In reality, relative to the long hydro penstock, a few correctly sized bends will make no noticeable difference as most friction loss is caused by the length of the penstock.

Readers familiar will ram pumps will note that the “Penstock” is called a “Drive Pipe”. Drive pipes for water rams always have to be as straight as possible, made of steel and always descending. This is not the case for a PHP Penstock which can use low cost plastic pipes, lay on the ground and meander down the river bank.

4.7.6. Laying and securing pipes

When laying the pipe try to do the following:

- Install a good strong intake structure.
- Secure the pipe against flash floods during the installation process.
- Obtain a good descent in the first few meters of pipe length.
- Lay the pipe on a gradual, always descending line where possible.
- Keep the number of high points to a minimum and vent these to avoid air locks, pressure rises and pressure drops.
- Avoid siphon systems.
- Once the pipe is in position, securely fasten the pipe line to rocks, trees, or ground anchors to prevent it moving down the incline or being washed away in flood events.

4.7.7. Penstock valves

You may wish to install a valve below the intake, but this is rarely useful. If you do install a valve at the top end of the penstock then the weight of water below will cause a vacuum that may collapse your pipe or draw debris into it. It is good practice to fit a vent pipe just below any such valve so the penstock can drain. This vent often helps air to escape while the penstock is filling.

The PHP turbine comes with a valve(s) that controls the individual jet(s), but you may also wish to put a larger valve on the penstock just prior to the manifold. Closing this valve allows you to work on the manifold without draining the penstock. It also means that the penstock can be filled and bled of air in advance of installing and commissioning the PHP turbine itself. The air can take time to find its way out via the intake and vents fitted.

You may need bleed valves at high points if the penstock slope is not continuous. These are only used to remove air and can be closed during operation.

Finally you may wish to install a flush valve at the bottom end of the penstock so that you can flush out sediment.

None of these valves are always essential - each has possible merits.

4.8. Intake design and placement

The intake for a PHP turbine should be positioned at the base of a small set of rapids typically no more than 300-500mm high (to allow room for a sloping intake screen as shown below). Water flows over the top of the screen falling into the chamber below that feeds the supply line. Leaves and twigs are washed away with surplus water preventing the intake from blocking.

Intakes often need to be made to suit each site. The examples below illustrate different ways to do the same job. The picture of the angled guides and screen is the recommended way to make a good strong maintenance free intake screen. You must ensure you securely attach the intake screen to the riverbed by driving galvanized stakes into the ground or attaching to large boulders with brackets, bolts and cement.


Angled screen


Flat screen in road culvert


Stainless steel perforated tube


Perforated galvanized cable tray intake


Angled guides and screen - the best!


Perforated box in concrete


Commercial intake on road culvert


Perforated Box

Stainless woven tube from scrap yard

Intake made from stainless steel scrap

Intake screens such as these can be purchased. However, they are easy enough to make to suit your site. You can use a stainless steel mesh and a plywood box, make sure you support the screen from behind with stainless steel rods/frame otherwise during floods the mesh will be pushed in. A fine, smooth stainless steel gauze with a hole size typically 1-3mm should then be placed over the stronger frame. This smooth gauze will allow debris to slide off easily and prevent small aquatic life forms from entering the pipe line.

Some ideas for intakes made from scrap stainless steel components

4.8.1. Water usage with minimum impact on the environment

PHP turbine systems may potentially affect:

- Plants and fish in the water.
- Plants and animals beside the water.
- Stream banks and surrounding land.

You must check with your local authorities to see if you need to obtain consent either to build any structures or to take/return water from a waterway.

Most systems divert a fraction of the main water flow through an intake screen, via the penstock to the PHP turbine. A good intake will lead to negligible erosion and the screen will minimize the chance of fish, leaves, etc entering the supply pipe. Taking less than 50% of the minimum seasonal flow rate in your water source means there is no impediment to fish moving up or down stream and hence gives aquatic life a better chance to survive.

You should take care to ensure that the exhaust water from the turbine can return to the river without scouring the bank of your waterway. Line the bank with concrete, timber or plastic sheet as required. Some systems utilise the exhaust water for irrigation, allowing the water to percolate through the soil before returning to the waterway.

Good example showing:

- Concreted river bank
- Timber boards to prevent river bed erosion

4.9. Turbine "manifold" connecting options PHP Turbine

The manifold is the system of pipes that connects your penstock to your PHP turbine jets. The penstock is what we call the main pipeline from the intake.

Up to five or more PowerSpout turbines are commonly connected to a single penstock. It is helpful if at the end of the penstock there is a large valve so the pipe can be flushed to purge sand/silt. PHP turbine manifold pipes are branched off the main run before this flush valve.

This section covers different ways that turbines can be connected in a cost effective manner. Parts for many of these options can be ordered at the same time as you order your PowerSpout PHP turbine. See the price list.

4.9.1. Connecting your pipe to the PowerSpout PHP

The ball valves supplied have either 2” female BSP threads or (for the USA and other countries that use NPT threads) a 2” BSP thread on the jet side and 2” NPT thread on the other side. Customers in the USA can buy NPT threaded fittings locally. (PowerSpout can also supply PVC manifolds for our PHP turbines with 2” BSP/NPT threads, see below.)

Penstock pipe fittings must be bought separately, as every site is different. For larger PE pipe sizes we have pipe joiners available for purchase that fit onto MDPE and HDPE pipe with the following OD: 63 mm (2.5”), 75 mm (3”), 90 mm (3.5”) and 110 mm (4.5”). These larger fittings can be ordered with your turbine.

4.9.2. Recommended manifold pipe sizes

For flows up to 3 l/s per jet, manifold pipe size ID should be 50 mm or larger
For flows up to 5 l/s per jet, manifold pipe size ID should be 65 mm or larger

The table below indicates the power loss in Watts per metre of pipe.
(Also an elbow or Tee fitting equals roughly 2 more metres of pipe.
Such losses tend to be negligible on a penstock, but important on small-bore manifolds.)

	Pipe bore in mm			
Flow l/s	40	50	65	90
1	1.8	0.6	0.2	0.04
2	3.6	1.2	0.35	0.07
3	5.4	1.8	0.5	0.1
4	7.2	2.5	0.7	0.15
5	9	3	0.9	0.2

4.9.3. Quick connections

The ability to quickly remove the PHP turbine from the pipework is important so that turbines can be easily serviced.

There are 2 common ways that a quick connection can be made:

- PVC mac-unions (solvent welded for rigid pipes)

- Plastic Camlocks 50mm (2”)
  Camlocks with flexible pipes (hoses) are a good solution.

4.9.4. The connections made to the penstock

You will need up to 2 penstock connections for every PHP turbine.

Connection to the penstock can be made in the following ways:

- Bolt over saddles and flexible hoses
- Pipe fittings - T's and Y's
- Our PVC 2 jet manifold – for PVC pipes and the PHP turbine

4.9.5. Bolt over saddles

These suite large multiple PHP insulations, available to order with your turbine for pipes with outside diameters of:

- 160 mm
- 110 mm
- 90 mm

You can install as many as are needed. They are double sided so provide 2 x 50mm BSP male threads per saddle set. Pictures below show how you install them on your pipes.
These saddles can also be used for making a large pipe vent just after the intake.

Once the saddles are fitted, use the valves and camlocks as shown. Note that the valves are fitted to the saddle and not to the PHP turbine. This ensures that the PHP turbine can be easily removed for servicing leaving the off valves in place.

Saddles have the following advantages:

- Low cost
- Less freight bulk and light in weight
- Easy to fit, no special tools needed

Saddles have the following disadvantage:

- Sharp take-off so higher fitting losses.

Saddles connected to PHP turbines via camlocks and flexible pipes suit all heads and flows up to 3 l/s per turbine jet with 50mm ID pipework. Most PHP turbines can be connected in this manner.

4.9.6. PVC manifolds for our PHP turbines

PowerSpout can supply PVC manifolds for our PHP turbines with either 2" BSP/NPT threads or 2.5" BSP threads. As PVC sizes are often different from one country to another, using a common thread size as a connection method is often the best way to avoid problems on site.

The picture shows two PHP turbines connected via PVC manifolds to a mac-union and then to the black plastic MDPE pipe via a threaded connection.

The penstock was separated into 2 lines prior to feeding each manifold by using a T and 90 degree elbows.

4.9.7. Pipe fittings - T's and 90 degree elbows

For many sites HDPE pipe fittings can be used to build a manifold.

You are likely to need

- T's
- 90 degree elbows
- Joiners
- Thread adaptors

If you are installing just 1-2 PHP turbines then it is likely you are using 50-80 mm OD MDPE pipe for your penstock. Offcuts of this pipe with some fittings can be used to make a low cost splitter manifold combined with a factory made PVC manifold as shown.

All the bends in the manifold opposite do not result in significant losses since the penstock pipe is 80mm ID; this splits into 2x80mm ID pipes, then this is split again into 2x65mm ID PVC pipes. This means that the water velocity in the PVC pipes is 1/3 of that in the penstock, so losses will be very low. We will show you how to check for penstock losses later with a pressure gauge.

4.9.8. Mock up your manifold off-site first

You will save a lot of time if you mock up your manifold and exhaust water collection off site where it is easier to work. This picture shows 2 x PHP turbines trial fitted off site prior to carrying all the parts 800m into dense forest. Note the mac unions so that the turbines can be easily removed.

4.9.9. Other manifold options

There are many possible manifold solutions; there are some pictures below to give you ideas for your situation.



4.9.10. Measuring pressure in your pipe and manifold

Pressure losses in your Penstock and manifold are normally in the range 5-33%. It's typically worth while using a large enough pipe for 5% loss (used as the default in the online calculator). If the penstock is exceptionally long then this may not be the most economic solution. A smaller pipe with higher loss may be dramatically less costly while providing sufficient net pressure.

It is very helpful if you can measure both the static and dynamic pressure at the end on the Penstock and just prior to the turbine jets. From these readings you are then able to determine the losses in the Penstock and the losses in the manifold. All PowerSpout PHP turbines include a pressure gauge(s).

4.9.11. Initial purging of the penstock

Walk the pipe from the bottom and lift sections that sag below horizontal so that air can escape upward. Fit riser vents as required. Small stainless screws (as shown) and marked with red tape can be drilled into the pipe (at air locks) and left to weep. In this way air can get out but very little water will be lost.

It may take several hours for the air to bleed out. While it is purging check the penstock and manifold fittings for leaks, and remedy as required. If outside small water drips will often stop by themselves after a few days.

4.9.12. Pipe supports

Make sure the pipe is secured firmly just prior to the turbine (note metal supports in picture). A large pipe full of water can be heavy and may need support. Bear in mind when securing flexible pipes that you may wish to manipulate the pipe itself during optimisation at set-up so as to find the best jet position/angle.

Pipes full of water are heavy and will sag over time. It is very important to provide support to all manifold pipes close to where they connect to the turbine. Pipes are normally supported as follows:

- A steel fence post, also called a T-post, a Y-post or a star post. These steel posts are hammered into the ground either side of the pipe. There are holes in the posts and timbers can be used to sandwich the pipes in place. Screws are used to hold the timbers to the posts.

- Aluminium rails and connectors commonly used for the mounting of solar PV panels can be used to support flexible pipes and provide adjustment as shown.

5. PHP Turbine Components

In order to reduce the length of this installation manual the parts list and instruction on how to service and assembly the PHP turbine are in a separate document "PowerSpout PHP how to assemble"

NEVER work on your PHP turbine while it is in operation.

6. PHP Turbine Installation and Commissioning

Before commencing the installation process you should have selected the appropriate components:

- Intake structure
- Penstock pipe
- PHP turbines(s)
- Delivery pipe
- Header tank

This manual includes information and links to relevant tools to facilitate this process. It should take no more than one day for two people to install a PowerSpout PHP turbine, depending on site terrain. Pipe laying can take much longer in difficult terrain.

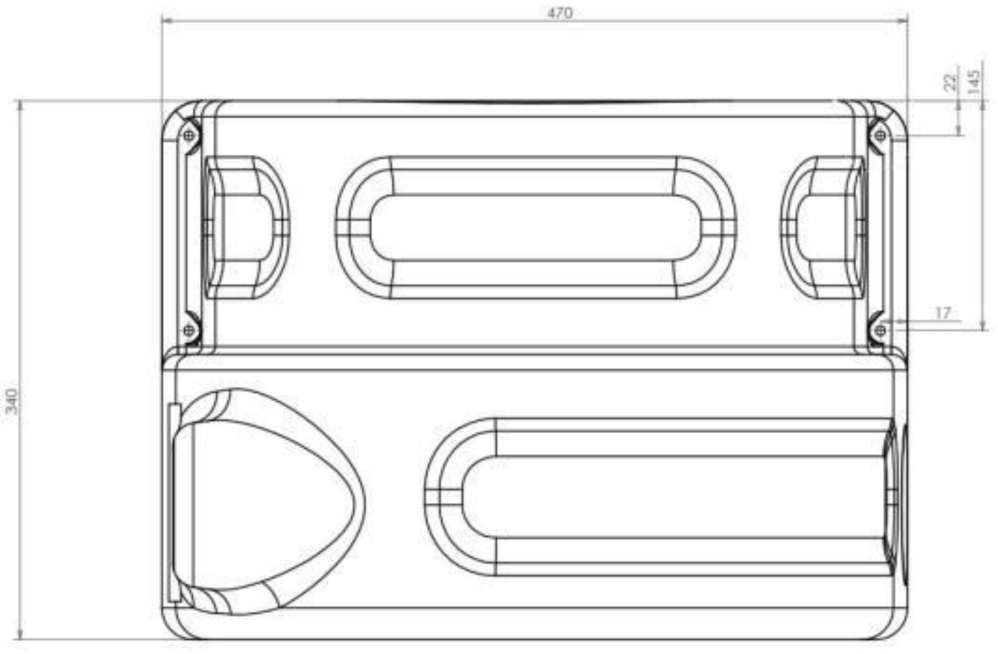
6.1. Mounting

Fixing a turbine to a timber base

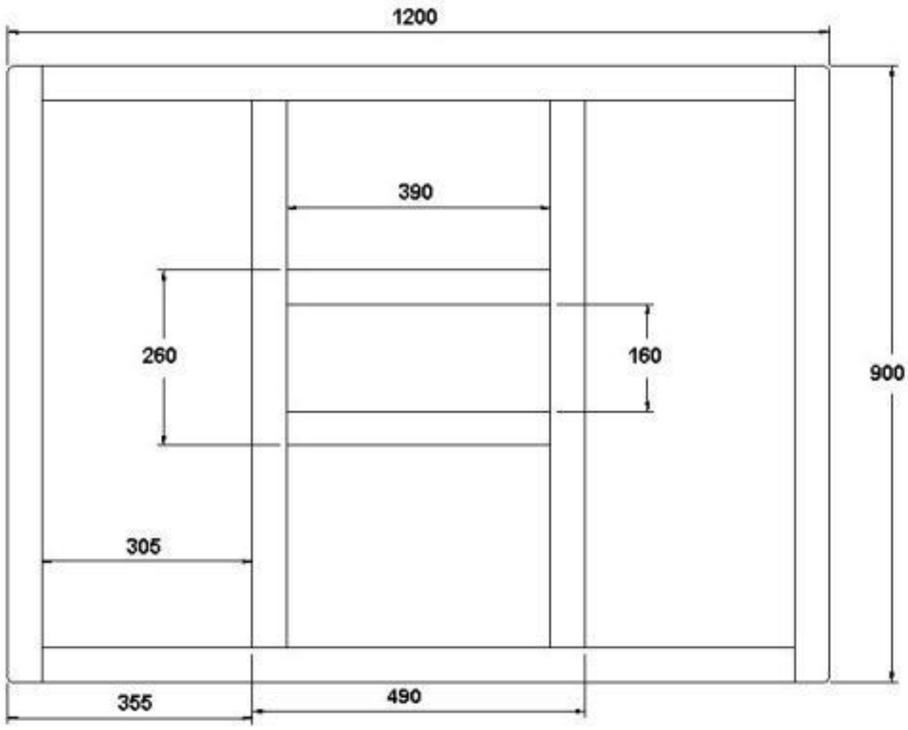
Clients often want to build the base for their turbine while their order is still being processed.
It is best to wait until your turbine has arrived before you complete this detail. There is nothing to beat having the turbine on site to avoid errors. Do not try and be too clever.
What follows is helpful dimensional information in the planning of your turbine location.

6.1.1. Mounting PHP turbine

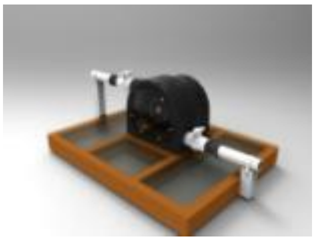
The main case dimensions (mm) and the four holes in the PowerSpout casing for turbine mounting are illustrated in the plan view below. Fixings are provided with the PHP turbine for connection to a timber framed base. These dimensions are sufficient to plan for the mounting of the turbine prior to its arrival on site. A PowerSpout PHP unit is 400 mm high.



Plan view of a PowerSpout PHP turbine



A TYPICAL PLT TURBINE BASE:
A framed timber base made from 100x50 timbers and covered in 12-17mm thick plywood sheet on top with **a hole 160 x 390 mm** cut for the exhaust water. Remember to drill a hole so that condensation can drain from the turbines dry side.



A timber or concrete turbine base is less likely to produce resonant noise issues than say a steel or aluminium base.

6.1.2. Indoor turbine mounting

At sites where no water leakage can be allowed (slip hazards for staff etc) you can attach sealing strips of adhesive neoprene to the base of the turbine before bolting it down to ensure the turbine is completely sealed around the base. On the PHP turbine the hold down fixings are at the rear of the case. To ensure complete sealing at the front of the turbine under the glazing you can remove front glazing and insert screws through the inside plastic lip to pull down the case at the front and ensure a tight seal all round.

We also advise that for indoors situation you have a perimeter lip on your turbine base. Some water seepage is inevitable over time. A lip will trap this seepage and it can then be drained off rather than spread over the floor.

In situations where there is a high risk of dropping tools into the floor sump you should cover the floor opening with stainless steel mesh so that any dropped tools or parts will not disappear under the floor. This tends to apply to industrial sites, this precaution is not required at domestic sites where the turbines are typically mounted outside.

A mesh (or exhaust pipe) over the exhaust water opening will prevent access into the rotating parts from underneath, thus preventing serious damage to the fingers of inquisitive children. It is important that the installer makes the site safe and that no rotational hazards exist.

6.2. Final assembly of your PowerSpout PHP turbine

PHP turbines are shipped fully assembled other than jet holders and PVC manifolds (if ordered).

As soon as you receive your PowerSpout PHP please unpack it and check your turbine for transit damage. Please inform the dealer from whom you purchased the turbine immediately if you find any parts that appear to have been damaged in transit or are missing. If the turbine is being freighted on to the end client then you must check it prior to this next freight leg.

6.2.1. Jets

The jet sizes determine the flow through the turbine, and hence the rate of water usage and the turbine flow output. Water usage may need to be adjusted to the available flow. If the jets are too many or too large then the available flow may not be sufficient to keep the penstock full of water.

Your PHP turbine will come delivered with pre-sized jets, based on calculations supplied. Final adjustment in the field is often necessary to optimize output as part of the commissioning stage. As flow conditions change throughout the year, jet sizes may need to be altered to optimize turbine output.

Extra jets are supplied with your turbine, and spares are readily available from your PowerSpout dealer.

6.2.2. Cutting the jets to correct size

The plastic tapering jets can be cut on site with a sharp knife. The jets are inexpensive so a trial and error approach can quickly determine the correct jet size. It is important to cut your jet to the correct size cleanly so that the water jet can break smoothly without spray. We recommend using a sharp knife and paring away at the jet, cutting from the inside edge out. With practice a very accurate and sharp edged jet can be prepared in the field. The taper gauge and knife supplied in the optional PHP tool kit and helps to make this task easy.

Holding the plastic jet within a spare holder sleeve and end cap will ensure the jet is held firmly while you cut it to size. Take care as it is easy to slip, which could result in a significant flesh wound. If you have Kevlar gloves, wear them.

Cutting the jet to size and checking it with the taper gauge

If you have plenty of water and want to pump the most amount of power that your pipeline can deliver (before pipe friction chokes the output power) you should set the jet size so that the pressure on the gauge drops to 2/3 of the static pressure.

6.2.3. Pelton (PHP) exploded view

Turbine arrives fully assembled, other than the jet holders. This exploded diagram will assist you once it comes time to service the turbine. Click here for the service manual.

Installing jet assemblies

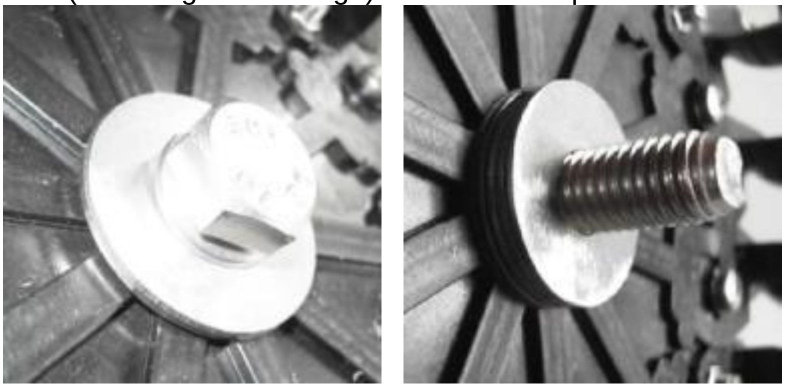
The PVC jet sleeve is mounted inside the turbine with the PVC ball valve on the outside. Note that there is also an ‘O’ ring that fits on the jet sleeve thread after being inserted through the casing. This ‘O’ ring ensures that the valve and jet sleeve seals onto the casing and does not leak. The ‘O’ ring is on the **outside of the casing**. Grease all threads so that you can easily undo them in the future.

Jet assembly in position

It may be necessary to remove the front glazing and Pelton runner in order to install the upper jet assembly (if the turbine uses 2 jets). If so then follow the procedure below in reverse order.

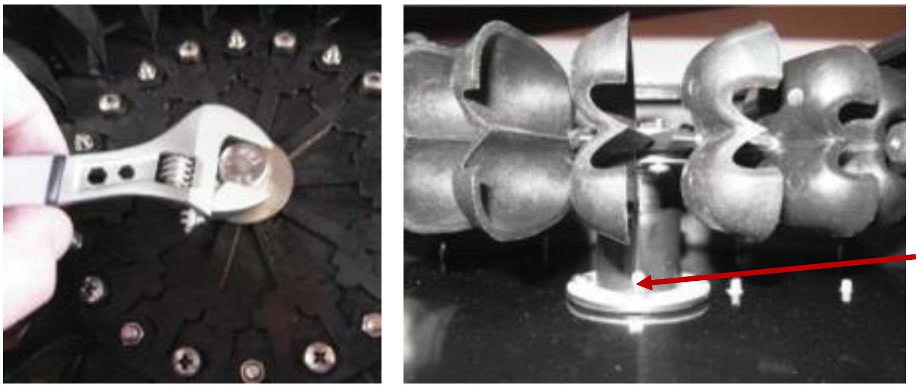
Installing the Pelton runner

Ensure that when you mount the Pelton runner you fit it the correct way round. The water jet should hit the splitter (the straight knife edge) of the Pelton spoons.



Pelton fixing washers front and rear views

- Insert M12 bolt, spring washer and washers as shown.
- Install alignment washers as shown. Note you may need to alter the position of the washers until the centre of the jet aligns with the splitter of the Pelton spoons.
- Attach the Pelton runner to the shaft as shown below.



Top hat
drain hole
points down

Attach Pelton runner to the shaft and tighten to 40 Nm (28 lb/ft).

Ensure that the drain hole in the slinger housing top-hat is pointing downwards.

Quick release glazing tabs

These tabs are provided with the PLT turbine to secure the glazing during commissioning. Use them during set up, as they make it easy to remove the glazing. The other fixings should be used later, for safety, if children have access.

Pelton Runner Alignment

You can view the Pelton runner by looking through the jet as shown. The water jet needs to hit the middle of the Pelton spoon splitter. If the jet is misaligned then pack the runner across using the washers supplied. You can see in the picture that the Pelton runner needs packing to move the rotor to the left.

If the manifold is flexible then alignment can be done later by moving the pipe supports while the turbine is running, while noting changes in speed.

6.2.4. Turbine Protection

The PowerSpout PHP is encased in a very durable LDPE housing, ensuring all internal parts are protected from rain, rodents, children and UV etc.

The LDPE enclosure also helps reduce noise and dampens any slight vibrations. The main benefit, however, is that there are no exposed rotating hazards that might catch the fingers, clothes or hair of interested children - ensuring a very safe product. Access to the rotating parts is only achieved with the use of a tool to remove the covers. All tools to do this for the PLT turbine are supplied in the optional tool kit.

6.3. Commissioning procedures

6.3.1. Checks with covers off - before install.

These tests ensure you have completed the plumbing connections and have no leaks.

By this stage you should have:

- Installed the intake and penstock
- Securely attached PHP turbine(s) to a suitable base
- Connected PHP valves to the penstock
- Connected a 25mm (1”) ID pipe from the penstock to the PHP low pressure input
- Connected the tank supply pipe to the PHP high pressure output
- Filled the PHP turbine will vegetable oil

6.3.2. Commissioning the turbine

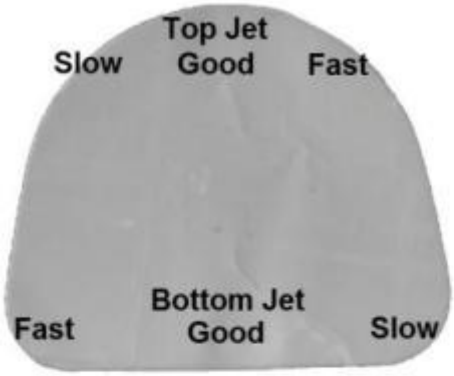
Turn the turbine on. It will spin and there should be very little noise. As the delivery pipe fills with water and the back pressure builds up, the turbine will steadily slow in speed. While the pipe is filling keep an eye on the Pelton spray pattern on the clear screen to observe what happens.

Optimisation may be required for all PowerSpout PHP turbines, especially in cases where the site data supplied for calculations is not accurate. This is very important and will make a significant difference to the volume pumped each day. The speed is adjusted by altering the cam stock once the jets have been correctly sized and any penstock airlock issues have been resolved.

If the exhaust water <u>bounces back</u> towards the jet then the turbine is running <u>too slow</u> or is **stalled** and you should fit a cam with less stroke.

If the exhaust water <u>travels through</u> and hits the opposite side of the casing then the turbine is running <u>too fast</u> and you should fit a cam with more stroke.

Too slow Good Too fast



The above illustration shows where the top and bottom jet exhaust water should be hitting the clear screen for optimal performance. The spray pattern may also give clues to any misalignment of the jet axis relative to the turbine buckets.

Optimisation is a trial and error process whereby you run the turbine and observe the spray pattern.

Generally a PHP turbine running a little too slow will pump more water per day than one running slightly too fast. But if it stalls or is very close to stalling you have to install a cam with less stroke.

If it runs too fast you can then install a cam with more stroke, to slow the PHP and increase pumping performance

Once optimisation of PHP turbine(s) is complete, the turbine exhaust water should be hitting the clear glazing at roughly 90 degrees to the jet.

If as the delivery pipe to the tank approaches full, the exhaust water bounces back significantly (turbine stalling), then one or more of the following is likely:

- Jets size is too small – check calculation file against your “as installed site data” and install larger jets if required.
- Penstock is air locked. The pressure gauge shows inadequate pressure. Walk up the pipe, locate remaining airlocks and purge them. You can often hear airlocks if you put your ear to the pipe. Also if you try to lift the pipe section it will feel light if air locked.
- Incorrect cam size has been installed – check calculation file against your “as installed site data” and install cam with less stroke

It is important to formally commission the turbine and associated system to ensure it is working correctly prior to leaving the site for the day. It may take time to test everything because the Penstock may need to be purged of air, the jets sizes adjusted and the cam stroke changed to suit the "as installed" site data.

Operating checks (with penstock purged)

- Check that the intake has surplus overflow water. If not then you may need to close some valve(s) or fit smaller jets before you can operate continuously.

6.4. Installation details

We recommend you take note of and let us know the final system details (as below) for future reference and to help with ordering replacements or upgrading the system.

This information **and a picture** of the final installation is required for all warrantees greater than 12 months.

Installation details	Serial number ______________________
Date installed	
Date for next service check	
Location of installation	
Penstock inside diameter	mm or inch
Penstock length	m or ft
Jet size fitted	mm or inch
Delivery pipe inside diameter	mm or inch
Delivery pipe length	m or ft
Static penstock pressure (turbine off)	kPa or PSI
Dynamic penstock pressure(turbine running)	kPa or PSI
Maximum delivery pipe pressure	kPa or PSI
Cam stroke installed	mm
Performance data	
Flow rate of water through PHP turbine	l/s or gal/min
Flow rate of water to header tank	l/day of gal/day

We would also like you to let us know your performance data so that we can determine conversion efficiency at your site. This helps us refine our calculations for future clients. As every site is different, efficiency will vary from site to site. Sites with input power less than 200W can expect reduced efficiency, refer to our warrantee terms.

6.1. Feedback

We welcome your constructive feedback on how we can improve our products, including this manual. Testimonials for our hydro products can be viewed at www.powerspout.com/testimonials/

As EcoInnovation endeavours to reduce their footprint in many different ways, e.g. to save on paper and airfreight, this manual is only supplied electronically to customers. We encourage users to minimise printing where appropriate and to provide feedback via our website or via email (see contact details inside front cover).

7. Operating your system efficiently

The PowerSpout PHP is a durable machine but it runs 24/7 so regular checks and maintenance are advised. A PowerSpout PHP may do more revolutions in a few years than a car engine during the life of the car. A car engine has a filtered and pumped oil lubrication system, whereas a small PHP turbine does not. A bearing maintenance schedule is outlined below and you are required to follow it if your 2-year warranty is to be honoured. Should you have a bearing failure during the 2-year warranty period we will ask to see your log book as proof you have followed the maintenance schedule.

To maintain your PHP in a good condition for years to come we recommend you keep a log book and regularly (every month initially, and once you become familiar with your system every 2 months) do the following:

- Check PHP hydro flow output is normal.
- Check you have surplus water at the intake. If not, reduce your jet sizes.
- Check there are no obstructions (twigs and stones) that have got in your pipe and are partially blocking the jets.
- Clean the intake screen.
- If you have a filter on the IPHP input line (where it connects to the penstock) clean this regularly.
- Replace the vegetable oil after one month and top up the filler cup will oil every 4 months

Every twelve months:

- Walk the Penstock and check for any damage to the pipe.
- Check bearing health by noting if there is any play on the cam shaft of the Pelton rotor.
- Replace oil.

Every two years:

- Change pump diaphragm every 2 years or more often if required. Every time you do this replace all the seals and the 4 one-ways valves.

We also suggest you are wary of complacency. Since these systems work and give free pumped water, people often neglect to do any checks until the pumps stops, they then run about trying to fix it quickly, but do not have the parts required on hand. A full set of spare seals is supplied with every pump. Once you use them remember to re-order them.

7.1. Spare parts

If you live in a remote part of the world you should consider having a full spare parts kit (or complete spare pump) on the shelf. This will mean that whatever the problem you can get your system going again quickly. At the very least you should hold spare diaphragm, bearings and seals; parts from NZ can take up to 10 working days to arrive to some global destinations.

7.2. Lubricating the PHP turbine

Refer to the document "PowerSpout PHP how to assemble"

7.3. Changing the bearings

Refer to the document "PowerSpout PHP how to assemble"

8. Troubleshooting

If you are concerned your PowerSpout PHP is not operating correctly then measure the delivered flow to the header tank and compare with the data supplied with your PowerSpout PHP.

- If the delivered flow to your header tank from your PHP turbine is within 10-20% of the design flow for your site then the PHP turbine is working correctly but may be in need of further optimisation of the jet sizes or cam stroke.
- If the delivered flow to your header tank from your PHP turbine are between 20% and 80% of the design flow:
  - Check that you have fitted the correct size jets.
  - Confirm you have sufficient water at the intake. If this is a first assessment of your PHP turbine installation then also check the accuracy of your water resource information supplied when you ordered your PHP turbine. The intake should be overflowing to some degree or you do not have enough water, or your penstock has a leak.
  - If the intake is overflowing, **check your pressure gauge against the design data**. If the static pressure (with valves closed) is low then you probably have air in your penstock, or possibly a major leak. If the running pressure is below expected level then you may have air pockets in the penstock or a clogged penstock intake. If pressure is high then you may have a blocked jet or jets.
  - Check your PowerSpout turbine for correct jet alignment, bearing health, correct Pelton runner packing and that no moving parts are rubbing and all pipes are connected.
  - Check the low pressure connection pipe from penstock to the PHP is not obstructed by debris or the filter (is fitted) is in need of cleaning.
- If the output flow to your header tank from your PHP turbine is less than 20% then do the above plus the following for your PHP turbine:
    - Check for a stalled (or almost stalled) Pelton rotor, fit a cam will a smaller stroke.
    - Check for over-speed of the Pelton rotor. Fit a cam with more stroke

8.1. Turbine case flooding

PHP turbines are often exposed to flooding risk. PHP turbines can handle submersion on rare occasions.

Immediately following a submersion of the PHP turbine you must:

- Drain the vegetable oil and replace it with new oil.

Damage caused by impacts events during flood events is not covered under warranty.

8.2. Noise

Noise is not an issue. The PHP turbine is very quiet. Hence if noise is an issue at your site you should check the following:

- The runner is not hitting the jets, it has been packed out correctly and packer washers have not been missed out
- The bearings are in good condition (Worn out bearings are a likely cause if the noise has increased gradually over time.)
- The unit is running at the correct speed. Incorrect speed can be caused by clients installing jets that are far too large or by installing a cam with a very low stroke.
- The noise is not related to how the turbine has been mounted. A heavy timber or concrete base will be quieter than steel/aluminium framed base.
- The line is free from air. Compressed air expansions at the jet are very noisy.

See section 17 for noise data. We have taken some representative noise level readings, as all hydro sites are different noise levels may vary from site to site but are generally low. Some clients are anxious over the noise issues as they have confused this PHP turbine with noisy water rams. PHP turbines do not use water hammer and are very quiet compared to water rams.

Generally the higher the head the more noise from the unit. But as the PHP turbine normally operate on heads <12m and rpm <500 noise levels are very low. Vegetation around the turbine will dramatically reduce the distance that noise carries to <10m.

9. Examples of good PowerSpout hydro system installations

Taking care in planning and installation, completing all commissioning tests, and observing and documenting correct operation are all the responsibility of the installer. Pictures of various installs follow, in the hope that these assist you in doing a quality job.

9.1. Good installations

This turbine install includes:

- Pressure gauge
- Good solid mounting platform
- Good water exhaust system
- Clean and tidy install
- Good all round access for servicing

9.2. Poor quality hydro systems

With a little more effort the installs below could have been made tidy, safe and compliant with recommended install procedures. Your system should be an asset not a liability.

Poor aspects of this PHP turbine install include:

- Turbine is not securely attached
- Main support (old chair) will rust out and the structure will collapse
- Site is not safe for access and service work

10. Units and conversions

To convert	To	Multiply by
centimeters	inches	0.3937
sq millimeters	sq inches	0.0015
Meters	feet	3.2808
miles per hour	feet per second	1.4667
Litres	gallons	0.2641
litres per second	gallons per minute	15.900

To convert	To	Multiply by
Inches	centimeters	2.5400
Feet	meters	0.3048
feet per second	miles per hour	0.6819
US Gallons	liters	3.7854
US gallons per minute	liters per second	0.0631

11. Warranty and disclaimer

The following applies to complete PowerSpout PHP turbines only and hence excludes kit sets and parts. Trade customers on selling this product must facilitate warranty claims with the final client. EcoInnovation will only deal with the Trade customer in such cases.

Our warranty is valid provided the turbine has been correctly installed (within 12 months of sale), commissioned and maintained over the duration of its use. The end user must return installation details[1] to EcoInnovation and keep a log book to record maintenance activity. EcoInnovation may request to see the log book and pictures of the installation and failed component prior to processing any warranty claim. The claimant must respond promptly to such an information request to ensure speedy processing of your claim.

EcoInnovation is confident in the performance, reliability and cost effectiveness of our range of water turbines. Hence we offer you:

- Full refund if you are not satisfied after the PHP turbine has been running at your site for a 30-day period (this must occur within 3 months of dispatch) and EcoInnovation must be given the opportunity to rectify the problem. Clients need to pay for return freight cost, and the PHP turbine must be returned in as new condition for a full refund. Site data supplied at time of order must be correct.
- Performance of our online calculation tool is an estimate; a margin of error of 20% applies. For sites under 200W input power a margin of error of 20% points applies to the conversion efficiency.
- A 10-year wet side erosion warrantee applies to the PHP Pelton rotor.
- A 2-year warranty from the time of purchase (invoice date) for PHP turbines operating at within our published specification and head up to 200m. For heads in the 200-250m range 12-month warrantee applies. The warrantee only applies to the original purchaser and is not transferable.
- All warranties are conditional on maintenance as specified in this Installation Manual including re-lubrication and replacement of bearings.
- Extended warranty available up to 8 years (extra premium applies).

[1] The warranty is only valid for 12 months if no documentation (see Section 6.4) is returned within 11 months of sale

- If there is a problem email us a picture of the nameplate and the failed part and we will fix it by dispatching a replacement part to you promptly. The labour cost to fit this part to your PHP turbine is not covered under this warranty. The warranty is limited to the supply of replacement parts within 2 years of initial purchase.
- To avoid any doubt, warranty starts from the date of manufacture as stated on the invoice from EcoInnovation to the buyer or dealer. As goods are made to order and dropped shipped (in most cases), this will mean that the end client may have 1-4 weeks less warranty by the time they receive the goods.
- The cost of any single replacement part outside the warranty period for the original purchaser of our turbine will not be more than $200 US plus freight (5 year limit from purchase date of turbine).
- Our maximum liability is limited to the full amount paid for the PHP turbine. If you are an overseas customer that has purchased this equipment by mail order over the internet then this is the maximum extent of our liability.
- EcoInnovation reserves the right to improve the product and alter the above conditions without notice.

EcoInnovation takes safety very seriously and we endeavour to reduce all risks to the extent possible and warn you of hazards. We encourage you to have the PowerSpout PHP installed by a professional installer if you do not have the skill, qualifications and experience to install this equipment safely. Customers that ignore such risks and advice do so at their own risk.

12. Exclusion and liability

The manufacturer can neither monitor the compliance with this manual nor the conditions or methods during the installation, operation, usage and maintenance of the PHP turbine. Improper installation may result in damage to property and injury.

Therefore, the manufacturer assumes no responsibility and liability for loss, damages or costs which result from or are in any way related to incorrect installation, improper operation, incorrect execution of installation work and incorrect usage and maintenance.

13. Contacts

In the case of complaints or faults, please contact the local dealer from whom you purchased the product. They will help you with any issues you may have.

14. Notes

Turbine type	………………………………………………………….
Serial number	…………………………………………………….....
Date purchased	………………………………………………..........
Date installed	…………………………………………………………..
Supplier contact details	…………………………………………………………..
Installer contact details	…………………………………………………………..

15. Annex I: Jet sizing tables

Jet sizing tables have not been published as the the advanced calculation tool can perform jet size calculations in metric and imperial for 1-2 jets, it is faster and more accurate than using a table. http://www.powerspout.com/calculators/

16. Annex II: Common PVC pipe sizes

The tables below are to assist in the understanding of the PVC pipe sizes available in your country. Countries that have sizes very similar to other countries are shown coloured the same, so they are easy to spot.

Table 2. NZ PVC Pipe sizes

OD of pipe	PN6 Wall mm	PN6 pipe mm	PN9 Wall mm	PN9 pipe mm	PN12 Wall mm	PN12 pipe mm	PN15 Wall mm	PN15 pipe mm	PN18 Wall mm	PN18 pipe mm	NB
48.3	1.7	44.9	2.1	44.1	2.8	42.7	3.4	41.5	3.9	40.5	40
60.4	1.8	56.8	2.6	55.2	3.4	53.6	4.1	52.2	5.0	50.4	50
75.4	**2.2**	71.0	**3.3**	68.8	**4.2**	67.0	**5.2**	65.0	**6.1**	63.2	65
88.9	2.6	83.7	3.8	81.3	5.0	78.9	6.1	76.7	7.2	74.5	80
114.3	3.3	107.7	4.9	104.5	6.3	101.7	7.8	98.7	9.2	95.9	100
140.2	4.0	132.2	5.9	128.4	7.7	124.8	9.5	121.2	11.3	117.6	125
160.3	**4.5**	151.3	**6.7**	146.9	**8.8**	142.7	**10.8**	138.7	**12.8**	134.7	150
225.3	5.8	213.7	8.4	208.5	11.1	203.1	13.7	197.9	16.2	192.9	200
250.4	**6.4**	**237.6**	**9.4**	231.6	**12.3**	225.8	**15.2**	220.0	**18.0**	214.4	225
280.4	7.1	266.2	10.5	259.4	13.8	252.8	17.0	246.4	20.2	240.0	250
315.5	8.0	299.5	11.8	291.9	**15.5**	284.5	**19.1**	277.3	**22.7**	270.1	300
400.5	10.1	380.3	14.9	370.7	19.7	361.1	24.3	351.9	28.9	342.7	375

NB refers to nominal bore which is the approximate inside diameter of the pipe series

Table 3. China PVC pipe sizes

OD of pipe	0.63 Mpa Wall mm	0.63 Mpa ID pipe mm	0.8 Mpa Wall mm	0.8 Mpa ID pipe mm	1.0 Mpa Wall mm	1.0 Mpa ID pipe mm	1.25 Mpa Wall mm	1.25 Mpa ID pipe mm	1.6 Mpa Wall mm	1.6 Mpa ID pipe mm	2.0 MPA Wall mm	2.0 Mpa ID pipe mm	2.5 MPA Wall mm	2.5 Mpa ID pipe mm
50	2.0	46.0	2.2	45.6	2.4	45.2	3.0	44.0	3.7	42.6	4.6	40.8	5.6	38.8
63	2.0	59.0	2.5	58.0	3.0	57.0	3.8	55.4	4.7	53.6	5.8	51.4	7.1	48.8
75	**2.3**	**70.4**	**2.9**	**69.2**	**3.6**	**67.8**	**4.5**	**66.0**	**5.6**	**63.8**	**6.9**	**61.2**	**8.4**	
90	2.8	84.4	3.5	83.0	4.3	81.4	5.4	79.2	6.7	76.6	8.2	73.6	10.1	69.8
110	2.7	104.6	3.4	103.2	4.2	101.6	5.3	99.4	6.6	96.8	8.1	93.8	14.6	80.8
160	**4.0**	**152.0**	**4.9**	**150.2**	**6.2**	**147.6**	**7.7**	**144.6**	**9.5**	**141.0**	**11.8**	**136.4**	**18.2**	**123.6**
200	4.9	190.2	6.2	187.6	7.7	184.6	9.6	180.8	11.9	176.2	14.8	170.4		
250	6.2	237.6	7.7	234.6	9.6	230.8	11.9	226.2	14.9	220.2				
315	7.7	299.6	9.7	295.6	12.1	290.8	15.0	285.0	18.7	277.6				
355	8.7	337.6	10.9	333.2	13.6	327.8	16.9	321.2	21.1	312.8				
400	9.8	380.4	12.3	375.4	15.3	369.4	19.1	361.8	23.7	352.6				

Table 4. USA PVC pipe sizes

OD of Pipe	Schedule 40 Pipe ID mm	Schedule 80 Pipe ID mm	OD of pipe	Schedule 40 Pipe ID inch	Schedule 80 Pipe ID inch
48.3	40.4	37.5	1.9	1.6	1.5
60.3	52.0	48.6	2.4	2.0	1.9
73.0	62.1	58.2	2.9	2.4	2.3
88.9	77.3	72.7	3.5	3.0	2.9
101.6	89.4	84.5	4.0	3.5	3.3
114.3	101.5	96.2	4.5	4.0	3.8
141.3	127.4	121.1	5.6	5.0	4.8
168.3	153.2	145.0	6.6	6.0	5.7
219.1	201.7	192.2	8.6	7.9	7.6
273.1	253.4	241.1	10.8	10.0	9.5
323.9	302.0	286.9	12.8	11.9	11.3
355.6	332.1	315.2	14.0	13.1	12.4
406.4	379.5	361.0	16.0	14.9	14.2
457.2	426.9	406.8	18.0	16.8	16.0
508.0	476.1	452.5	20.0	18.7	17.8
609.6	572.6	544.0	24.0	22.5	21.4

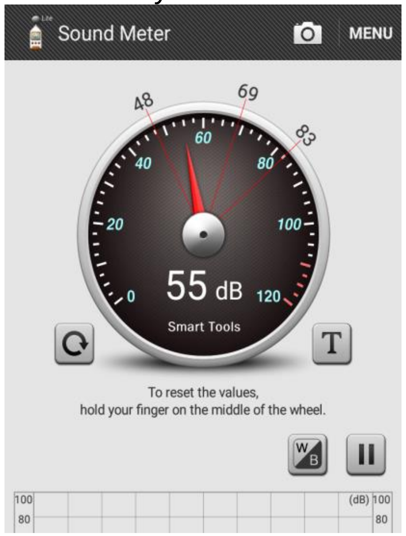
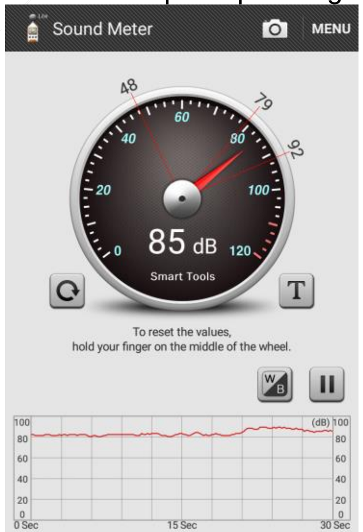
Provided in metric and imperial

17. Annex III Noise measurements

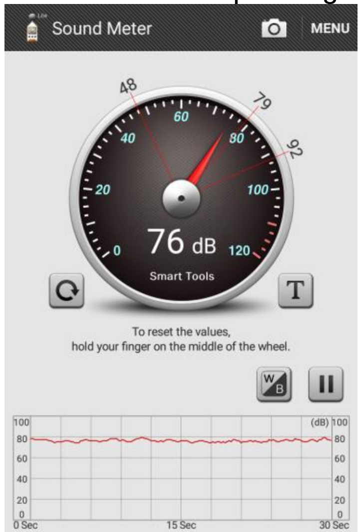
Noise test at PowerSpout on PHP turbine

Test parameters:

- Head: 3m
- Flow: 4 l/s

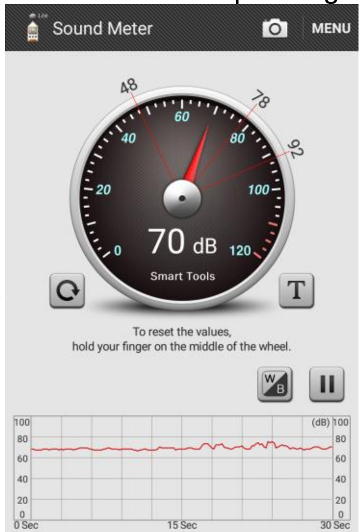
Background level on test day 5m from turbine – PHP turbine off	Sound meter on top of operating turbine
	
Trace 50-55dB	Trace 80-85dB

Sound meter 1m from operating turbine



Trace 75-80dB

Sound meter 5m from operating turbine



Trace 70-75dB

Sound meter 15m from operating turbine

Trace 50-55dB

