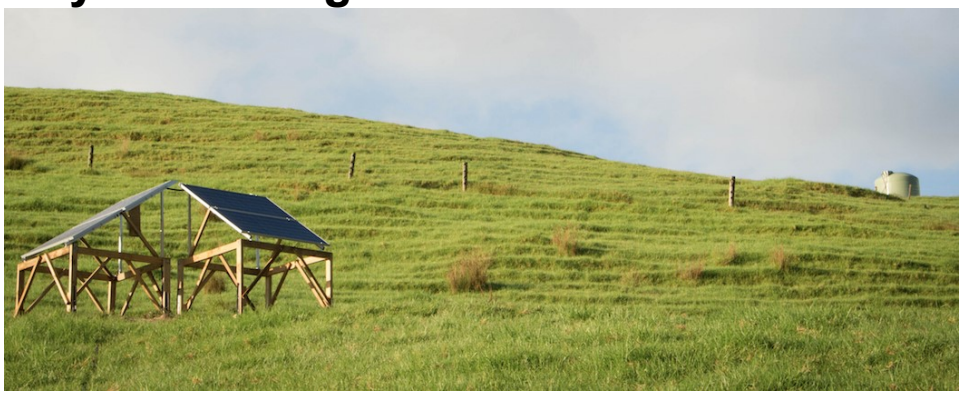
SHP-Triplex (Solar Hydraulic Pump)
System Design and Installation Manual



1080W of PV on movable frames (540W per frame)

SHP-Triplex pontoon mounted

Please read this manual carefully before beginning the installation.

August 2019 Version 1.5

SHP-Triplex ground mounted adjacent to a farm pond

Please read this manual carefully <u>before</u> beginning the installation.

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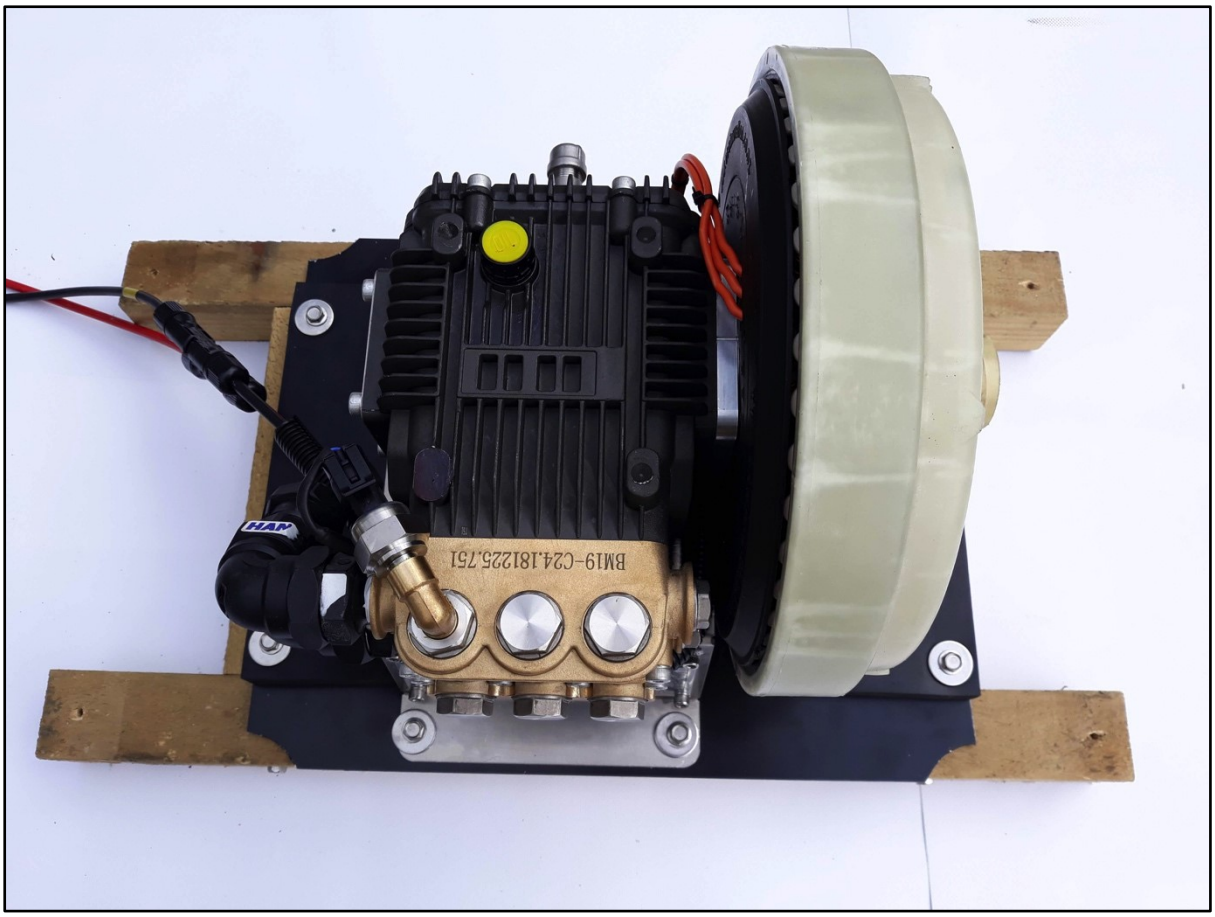
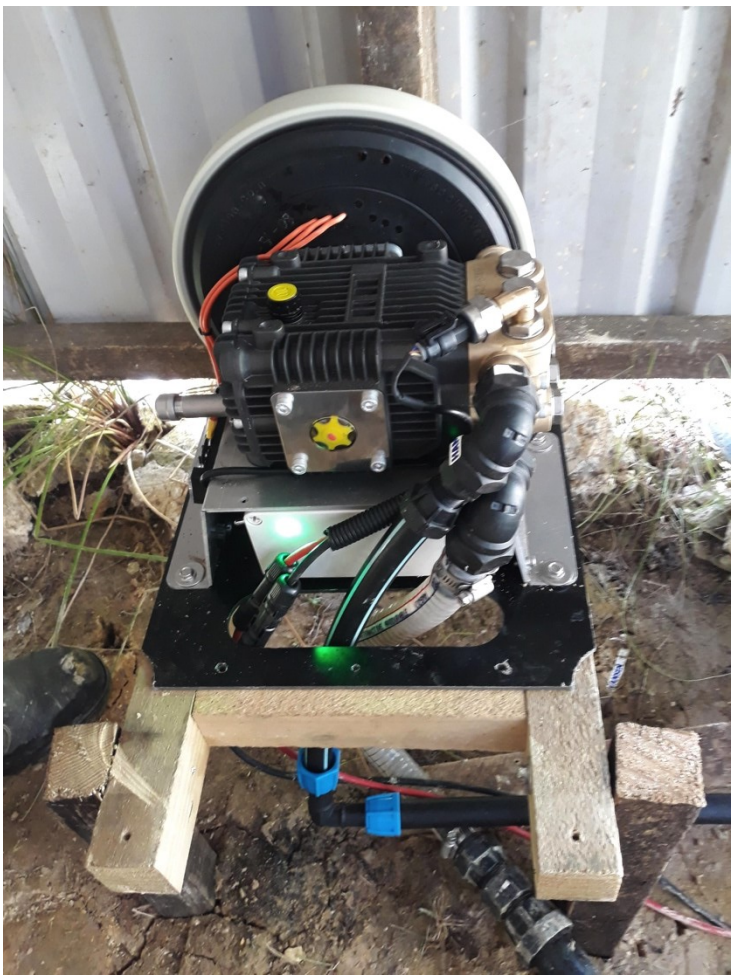


SHP with fairing removed

Fairing in place

Typical East/West Truss mounted array remote from the SHP-Triplex location



SHP-triplex shed mounted (with fairing removed)

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1.0	New release February 2019 content by ML, edited by HP & EL.
1.1	Minor typing corrections and additions 7/3/2019 by ML
1.2	Minor typing corrections 27/3/2019 by ML
1.3	Clearer advice on string protection when >2 PV strings installed by HP & ML
1.4	Corrections to section 1.1.2, to align with web site options by ML 29/9/19
1.5	Image update minor by ML 30/10/19

Ensure you are reading the latest version.
The most recent release of all our products documentation can be located in our INDEX here.

PowerSpout Contact details

Web: www.powerspout.com

If you cannot find the answers to your questions about our products, renewable energy systems, or your site's potential in this document or on our website at www.powerspout.com, please submit a question via email to any of the dealers listed on our website. We will answer this as quickly as possible.

PowerSpout is a product proudly designed and manufactured by:

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1. Scope of Application and Safety

This document is part of the product. It refers to the PowerSpout SHP-Triplex (Solar Hydraulic Pump Triplex version) and the associated PV array, wiring and pipe connections.

1.1. Scope

The product is designed to pump fresh water with the use of solar power (or other power sources) in the following conditions:

- Water that will not corrode aluminium parts. Seawater is not permitted.
- Dirty pond water is acceptable **within reason**. River water that includes pumice or other sharp abrasive material must be adequately filtered.
- Sub-zero conditions, do not install in situations where the pipeline may freeze or in temperatures below -6°C. Protection from freezing for colder climates is outlined later in this document.
- 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 (i.e. insurance cover). Product warranty does no cover such events.
- The client has read the manuals, viewed online videos and understood installation examples before starting on this project.
- We advise engaging an experienced/qualified installer who has good mechanical, electrical, plumbing, reading and comprehension skills if you do not possess these skills yourself.
- The SHP must be sited above any flooding level unless pontoon mounted. SHP submersion will result in serious equipment damage.
- The SHP, solar PV array and power cable must be adequately protected from large animal damage.

1.1.1. The client must determine:

- Vertical lift from the SHP centre line to header/storage tank.
- Size of header tank to meet their needs.
- Length of pipe to the header tank.
- Inside diameter of pipe to the header tank (already installed or available to purchase) to allow for the extra friction pumping head to be determined.
- Suction lift (vertical distance) from the lowest level of the water resource surface to the SHP centre line (if a floating SHP on a pontoon is not being employed).
- The suction pipe length. This must be less than 5m long, or the suction pipe size will need to be increased from the 25mm ID (supplied in NZ) to 30mm ID.
- Maximum daily water requirement in summer, or the driest season.

1.1.2. Items that are provided with all pump sales (NZ & International):

- SHP-Triplex pump with pressure limit control
- Thick rubber vermin guard
- Inlet and outlet fittings (outlet fitting rated up to 16 Bar)
- Non-return valve for supply pipe to storage tank
- Foot valve, pipe clamp, stainless mesh filter cage to go inside filter bag & 2x filter bags
- 7 x pairs of MC4 matching connectors
- 1 x pair of twin parallel connectors (for up to 4 panels – 2 strings)
- 1 x 30 amp DC switch with MC4 connectors
- Stainless steel & ACP fairing with strap

Optional extras are:

- High Head Upgrade - High Power PMA & stainless steel inlet and outlet fittings for heads >16 Bar
- 25mm ID clear suction hose

We can also supply:

- Fixing kit (50mm SS Tek Screws x4)
- Float switch
- Additional MC4 connectors
- 15 amp MC4 inline fuse
- Spare foot valve
- KWhr meter
- Flow meter
- Seal service kit and valve set (x6)
- Plunger ceramic liner set (x3)
- System design service

For New Zealand Customers we can also supply:

- 540W PV array
- 1080W PV array and one MC4 2-1 branch connector set
- 1620W PV array and one MC4 3-1 branch connector set
- Red solar PV wire
- Black solar PV wire
- PV panel aluminium racking
- Installation service (within 2 hours drive of New Plymouth)

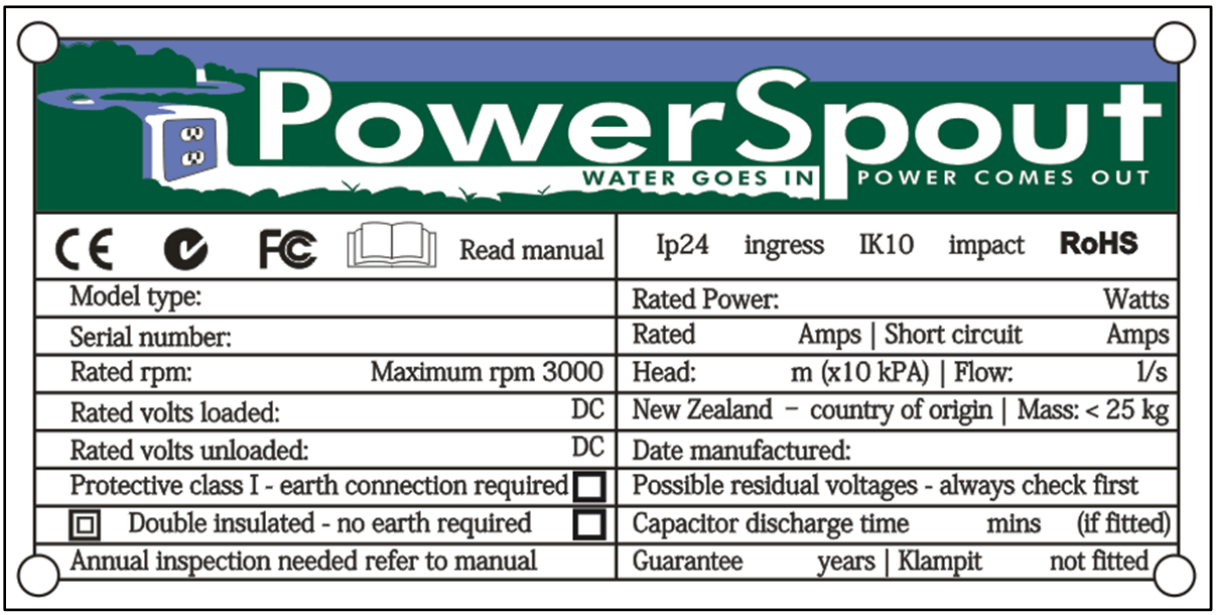
Note: Some items above may be provided by a local dealer/supplier/installer in your country or you can source them yourself. Many will be available on our website at the time of purchase for an additional charge.

Note[1] Nominally based of 270W pairs. Panels in the range 250-325W are also acceptable refer to 12.1.1.

Note[2] PV panel ratings tend to increase by 5W/per for the same size. The best price panel today (2019) is likely to be 280W. Last year it was 270W. **This manual and examples herein mainly refer to 270W panel examples.**

1.2. Pump serial numbers

All SHPs have identification plates and serial numbers. We use the same plate as on our hydro turbines.



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

This means you have:

- Job number 3678

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.

1.3. Safety

The following safety warning signs are used throughout this manual.

Caution
Risk of electric shock. On this Solar ELV (extra low voltage) pump system electric shock is very unlikely if these instructions are followed. All voltages are ELV if the solar panels are correctly connected together. Incorrect connection of 3 or more solar PV panel is LV (over 120VDC) and can result in electrocution (and/or damage to the SHP-Triplex speed controller).

Caution
Cautions identify conditions or practices that could result in damage to equipment, fire, or personal injury, other than by electric shock.

EcoInnovation will not be liable if you connect this equipment incorrectly and in doing harm yourself, harm others, cause a grass/bush fire or damage other equipment in your system.

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 until after you have read this manual and watched all relevant videos provided. Our INDEX provides links to all these documents/videos.

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.

1.3.1. Rotational Machinery Safety

The PowerSpout SHP is rotating equipment and is provided with a stainless steel protective enclosure. There are rotational hazards present if the protective enclosure is removed. The SHP must be turned off at the DC switch(s) prior to removing the protective enclosure. It is also possible to turn off the SHP (if the PV array is distant) using the "ignition switch" which is located inside the protective enclosure (on the end of the microprocessor enclosure). This can be also wired to an external switch if required.

Note: an SHP can start rotating without warning if the DC switch is on and the microprocessor switch is on.

Once the SHP has been commissioned, the protective enclosure needs to be fastened in place with the latching tie-down provided.

The installer should ensure that the SHP is mounted such that inquisitive children are not exposed to a rotational machine hazard.

1.3.2. Pressurised Water Safety

In most countries, legislation covering pressurised pipes applies for pipe pressures over 10 bar (100m head). The PowerSpout SHP often operates at more than 10 bar. It is capable of pumping to 30+ bar (300m head). 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 and that the pipe's pressure rating exceeds the pumping pressure will eliminate such risks.

1.3.3. Fire Safety

Solar pumping is often done in very dry parts of the world. In tinder-dry conditions the risk of fire can be extreme. These manual instructions comply with AUS/NZS 5033:2012 and AS/NZS 4509.1:2009, as such if installed as per this document the installation meets the requirements in NZ and Australia for ELV systems. Not all countries have the same rules and in many countries the rules are not clearly defined. Check with your local electrician and fire department if you are unsure on the rules in your country. Also call your insurance company to check that your cover meets your needs in this regard.

Warning: if you do not comply with standards/codes and laws in your own country then your fire insurance may not be valid and if your **inadequate** installation of this SHP were to cause a fire you could be **personally liable** for any damaged caused.

- The electronics in the SHP are contained in a metal enclosure to reduce the fire risk.
- The smart drive motor (stator and rotor) are made from fire resistant UL listed plastic and are the same parts used in Whirlpool washing machines.
- The pump outer casing is a metal skin. This product does contain a small amount of combustible plastic material.

Where the risk of grass and forest fire is real in your area, the following measures shall be taken:

- Mount the SHP on a concrete base at least 1m square.
- Ensure the SHP is shaded if exposed to high summer temperatures. The BLDC motor and pump do need cooling airflow. Provide shade but do not enclose it.
- In pontoon applications (see pontoon section) no additional fire protection is needed).

Assessing the fire risk is the owner/installers responsibility:
The precautions you need to take are the same as for petrol/diesel water pumps, which have a high fire potential. The risk is small but the consequences can be very high, so please take the time to ensure that your installation is fire safe.

1.3.4. Electrical Safety: ELV Wiring rules specific to NZ and Australia

Two definitions exist in NZ for ELV ("extra low voltage"):
Any voltage **normally not** exceeding 50 volts AC or 120 volts ripple-free DC
Any voltage **not** exceeding 50 volts AC or 120 volts ripple-free DC

AS/NZS5033 also defines “ripple free DC” as:

> 1.4.62 **Ripple-free D.C.**
> For sinusoidal ripple voltage, a ripple content not exceeding 10% r.m.s.
> NOTE: The maximum peak value does not exceed 140 V for a nominal 120 V ripple-free d.c. system

All extra low voltage wiring should be performed by a 'competent' person, defined by NZS4509.1 as:

> "a person who has acquired through training, qualifications, experience or a combination of these, knowledge and skill enabling that person to correctly perform the task required"

Note – even with a reduced shock hazard there is danger of fire from incorrectly installed ELV wiring systems. Note the word should is advised (best practice) and not a legal requirement in NZ. ELV work in NZ is classified as “non prescribed electrical work”. So you cannot break the law as the law does not apply to this work. Do a quality job and seek paid assistance if/as required.

This document and supporting videos are sufficient training and knowledge to enable a capable owner/installer to perform the tasks required. If you feel you are not capable and do not have the time to fully read and view our installation material (to become capable and competent) then engage the services of an Electrician or Renewable Energy Installer/Technician.

Wiring is simple. You will need to attach MC4 connectors from the Solar PV switch box to the pump as the wire length/size will vary from site to site. All that is required is for the installer to plug together the waterproof connectors (in the correct sequence) and secure the wiring as per our supporting videos. If using three or more strings of solar panels you should determine whether there is also a need for string fuses in the design. (See 3.2.3)

1.3.5. Installation Safety Checklist

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

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

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 and standards.
- Read and comply with this installation manual and supporting videos.

PIPES

- Ensure both the suction pipe and the tank supply pipe are of the correct size. Undersized pipes will reduce SHP performance and can result in pressure blowouts and failure of the SHP to operate. There is a section later in this document to assist with pipe sizing.
- Do not confuse pipe ID with pipe OD when purchasing pipe.
- Use standard LDPE, MDPE or HDPE pipes. The pipes must withstand the maximum total pressure to which they are subjected. A safety margin is already included in the pipe rating. In hot dry climates where the pipe lays on the ground the pressure rating must be reduced to allow for the maximum temperatures.
- If necessary bury the pipe to protect it against heat, stock damage, 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 fitted with a non-return valve close to the SHP so that it can be easily removed for servicing.
- The SHP includes a digital pressure sensor that monitors the pressure and will turn off the pump when a set pressure is reached. The pump will stop if is detects a pressure above 300m, this can be easily adjusted downwards or reset (a reset returns default to 300m).

COMMISSIONING

- Securely fix the pump base prior to operation, at least 300mm above ground level to allow for pipe and wire connection that enter via the underside.
- Ensure:
  - Rodents cannot get access inside the pump.
  - Grass and other vegetation are prevented from growing into the pump via the cooling vents. Cover the ground with corrugated steel or concrete to prevent plant growth if required.
- Do not run the pump without first adding oil. Each pump has been tested at our factory for 1-2 days, but this testing oil is drained out prior to freighting.
  Fill the pump body with clean SAE20W/30 oil or any similar quality general-purpose multi-grade engine oil to the centre of the oil level indicator glass. Oil level should never be less than the bottom edge of the level glass or higher than the top edge.
- Do not intentionally run the pump without the water supply connected for more than 10s. Water is needed to cool and lubricate the ceramic plungers.
- Do not run the pump at a supply head above 300m.
- To turn on the pump you must ensure:
  - Solar panel switch is on.
  - If pump fails to rotate check sunlight is on panels and that the microprocessor switch is on.
  - Any float switch connected to the “float switch” connections is on
  - Wiring has been done correctly
- In a pump runaway situation (where the high pressure output pipe bursts) turn off the DC switch to stop the SHP.
- If you start the pump against a closed valve this will stall the pump. (You may also burst your pipe or fitting.) It may also go into sleep mode as it thinks your water tank is full. Turn off the solar power at the switch and wait 30s. Open the valve, turn the switch back on and it will run fine.
- Check for excessive noise. There should be little noise from the pump. Get familiar with what your SHP normally sounds like.
- Check water is being pumped at the expected rate for the sunlight conditions.
- Ensure that all protective fairing/enclosures are locked in position after commissioning.

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- Complete sensible signage requirements to help with pump maintenance and as required for AS/NZ 5033 compliance.
- Complete all documentation.
- Make relevant notes in the manuals that will be of assistance to future service personnel.
- If Installing the SHP for a client then all of the above must be complete before client handover.
- Train the client/user of the pump in routine care and maintenance of the SHP and solar system.

1.4. CE and FCC Declaration

Refer to PowerSpout Document INDEX for compliance declaration documentation.

The SHP pump contains electrical or electronic components.
The SHP will be tested for radiated emissions as soon as practically possible.
The fact that the BLDC driver and Smart Drive BLDC motor are mass-produced & globally available means that it is likely that they already comply. We will provide an EMC lab test report in due course. Once tested the certificate can be located in our INDEX.

1.5. Standards and certification

All PowerSpout pumps have been evaluated against the relevant sections of major international standards in regard to rotational machine safety and the restriction on the use of hazardous materials in the manufacture of the SHP.
The SHP has a metal casing and meets product safety, impact durability and freight drop test requirements.

Refer to PowerSpout Document INDEX for more information.

1.6. Consents and environmental impact

1.6.1. Frame building consent

No building permit for the PV array structure is required as it is less than ten square metres, and not a dwelling.

1.6.2. Electrical wiring COC (code of compliance)

An SHP is electrically safe (when correctly installed) as it runs at ELV (typically 57-80 VDC range) and hence does not need a COC and is very unlikely to be an electric shock hazard.

1.6.3. Water abstraction resource consent

For stock water and domestic home needs no consent is required in almost all cases.

1.6.4. Water usage with minimum impact on the environment

SHP systems may potentially affect:

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

Local authorities in NZ do not need to provide consent to pump water for stock and domestic home needs, it is a permitted activity unless your resource is the habitat for an endangered species.

If however, you intend to build a buffer storage pond in the water way consent may be needed, always check first to see if you need to obtain consent to build any structures or intakes in the waterway.

You should take care to ensure that the overflow water (if the SHP pressure stop is not to be used - you need a ball cock in your header tank for this feature to work) from your header overflow can return without causing erosion.

1.6.5. SHP's Noise Levels

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

This is not the case for most fuel engine pumps or water rams, which are very noisy.

2. Product Overview

Congratulations on your choice of a PowerSpout SHP-Triplex. This ingenious little pump will give you years of trouble free water pumping, avoiding the need for more expensive solutions. Not only does the PowerSpout SHP-Triplex give you renewable energy, it is also made from 25% recycled materials, making it the most eco-friendly solar pump available on the global market.

Efficiency is the measure of the pump's ability to convert solar energy into moving water against gravity. The PowerSpout SHP commonly averages 40-50% efficiency with 64% peak (when input power exceeds 700W and lifts approach 300m), which is superior to all other products on the market, meaning that it will move more water using a given solar array size. For a document that compares the PowerSpout SHP to other solar pumps and other methods of water pumping click here.

All PowerSpout SHP's are shipped fully assembled. We will provide a service guide for the SHP in due course.

Videos and other documents to introduce PowerSpout SHP are available here:

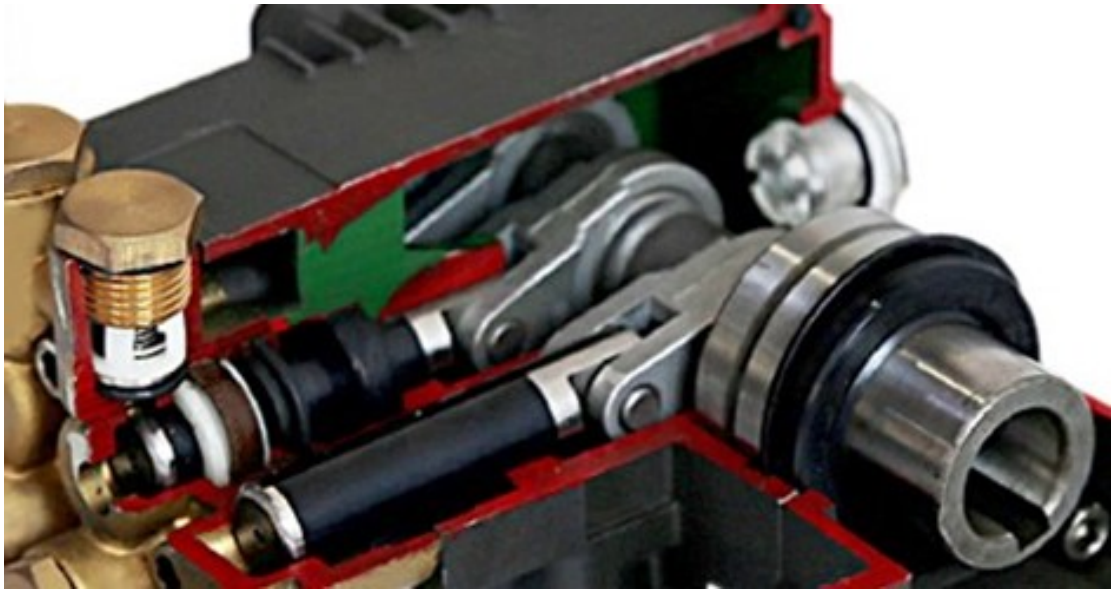
- SHP promo video (old diaphragm version but gives you the general idea)
- SHP installation videos
- SHP comparison document

Please note that video clips are indicative only and do become out-dated quickly and may not be up-to-date. Where instructions differ, the latest written manual (available online) will always be the correct method to follow. If you are reading this document then please check you have the latest version.

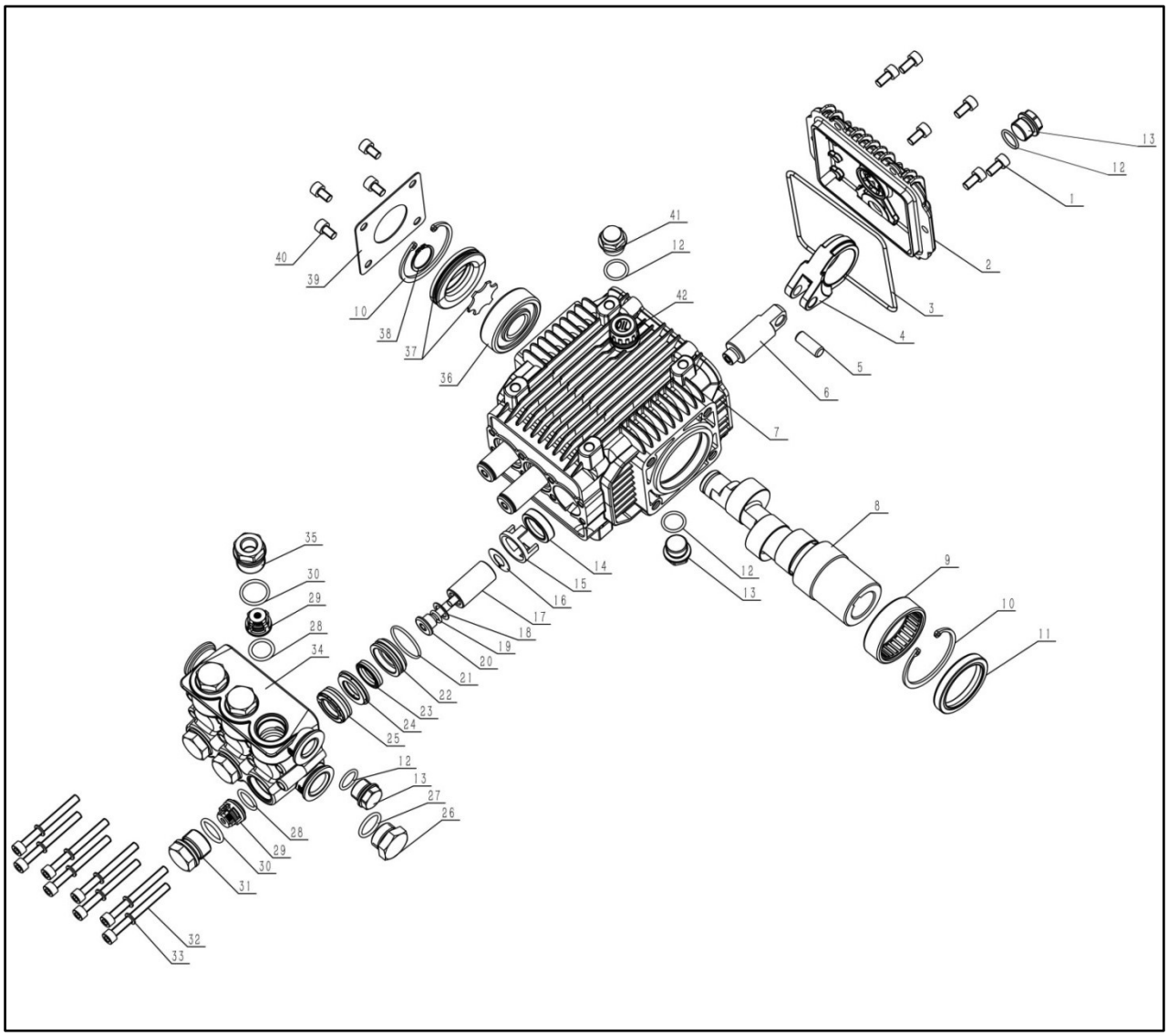
2.1. Product up close

The following pages contain images and information about the product. Please note that the solar panels can be mounted in many different ways, array images are illustrative only. If outside NZ please feel free to copy what we have done for our NZ clients.

2.1.1. Image cutaway of SHP-Triplex pump



2.1.2. SHP-Triplex pump exploded view and parts list (14mm stroke with 20mm diameter ceramic plungers)



2.1.3. Pump parts list

Part Number	Quantity	Description	Consumable part
1	4	M6 hex bolt for rear cover (5mm A/F hex)	
2	1	Rear cover with oil level glass	
3	1	Rear cover seal	
4	3	Big end bearing	
5	3	Gudgeon pin	
6	3	Plunger base	
7	1	Pump body	
8	1	Crank shaft	
9	1	Crank shaft front bearing	After 2 years
10	2	Crank shaft front & rear retaining circlip	
11	1	Crank shaft front seal	After 1 year
12	2	Oil drain/filler O-ring seal	After 1 year
13	2	3/8 BSP oil plug	
14	3	Oil seal for plunger base (6)	After 1 year
15	3	Plastic spacer	

16	3	Ceramic piston seating washer	
17	3	Ceramic plunger liner	Yes
18	3	Ceramic plunger seating washer	Yes
19	3	Ceramic plunger sealing O-ring	Yes
20	3	Ceramic plunger liner bolt	
21	3	Brass ring O-ring	
22	3	Brass ring	
23	3	1st plunger seal	
24	3	Plastic seat	
25	3	2nd plunger seal	
26	3	½ BSP suction plug	
27	3	½ BSP suction plug O-ring seal	
28	6	One-way valve seat	Yes
29	6	One-way valve	Yes
30	6	One-way valve plug O-ring seal	Yes
31	5	One-way valve plug	
32	8	M6 hex bolt for plunger head (5mm A/F hex)	
33	8	M6 split washer for plunger head bolt (5mm A/F hex)	
34	1	Brass plunger head	
35	1	One-way valve plug (see 31) for ¼ BSP for pressure switch	
36	1	Crank shaft rear bearing	
37	1	Oil level glass	
38	1	Crank rear retaining circlip	
38	1	Read bearing cover plate	
40	4	M6 hex bolt for rear cover (5mm A/F hex)	
41	1	Transit plug	
42	1	Oil vent and dip stick	

Note: consumable parts **<u>are not</u>** covered by warranty, as the life of these parts depends on:

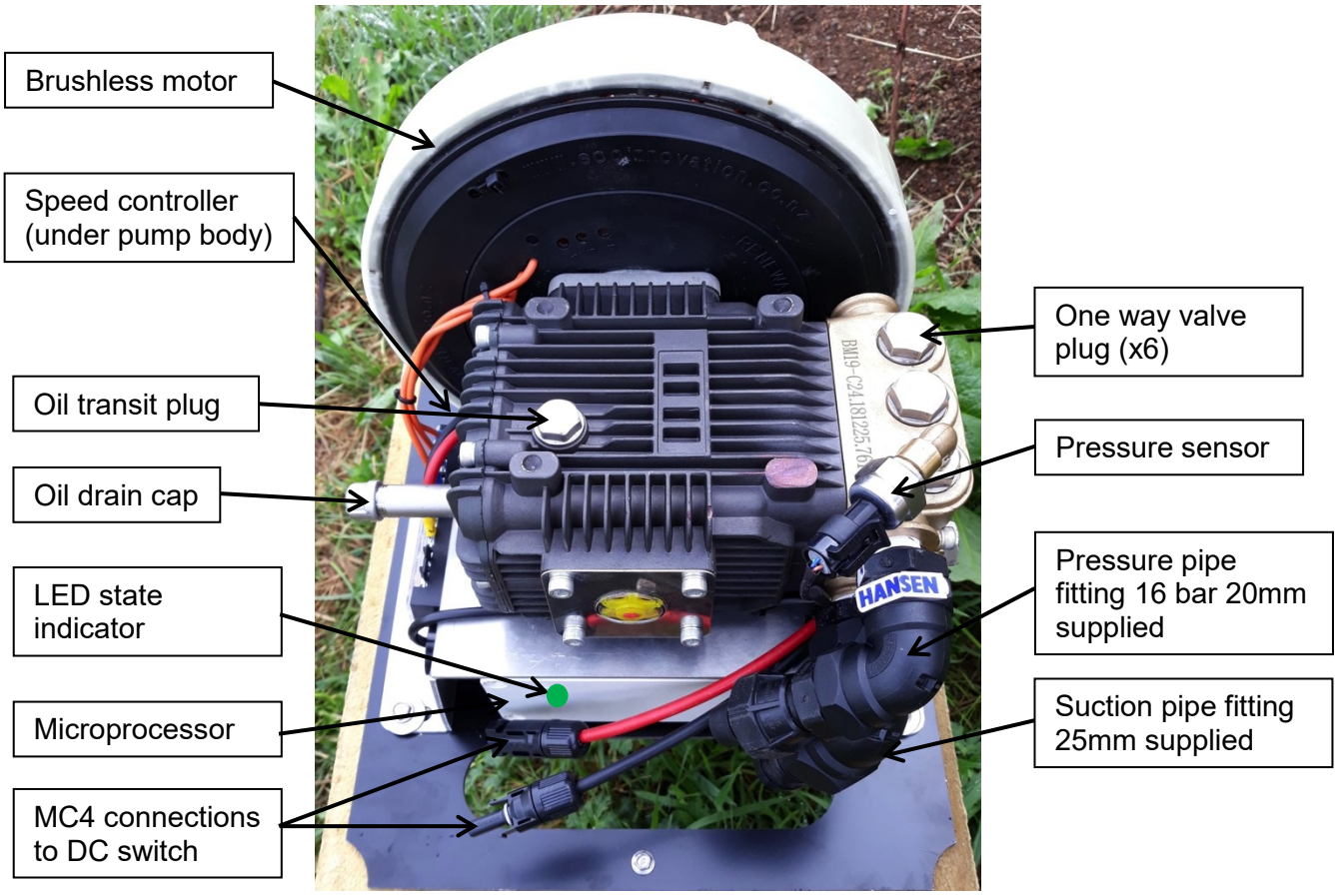
- Cleanliness of water pumped.
- Oil changes performed.
- Run time hours.

Normally all consumable part (unless stated otherwise) should last more than one year if installed correctly as per this guide.

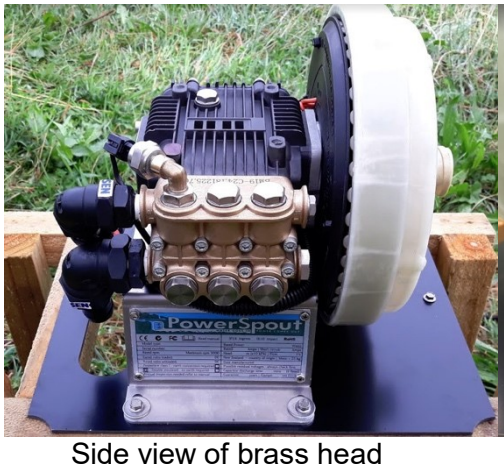
This pump was originally designed to pump up to 100 bar (1000m of water head) using a 4000W AC motor for commercial car forecourt cleaning machines. We use it for lifts up to 300m, running at slower speed with input powers up to 900W. So it is very conservatively rated.

2.1.4. Image of SHP with body fairing

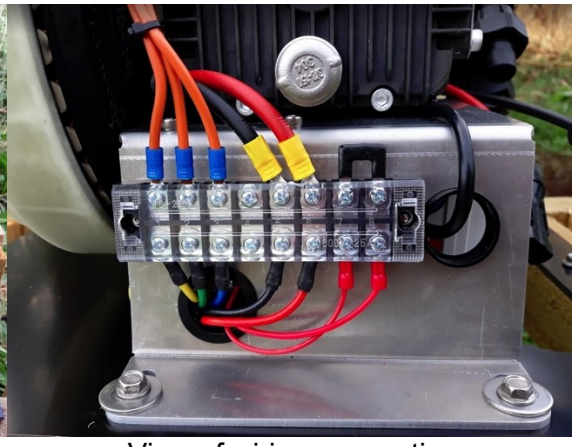
2.1.5. Image of SHP pump (with body fairing removed land mounted)



Note a thick rubber pad is supplied to cover the gap between the pipes and base plate to keep rodents out.



Side view of brass head

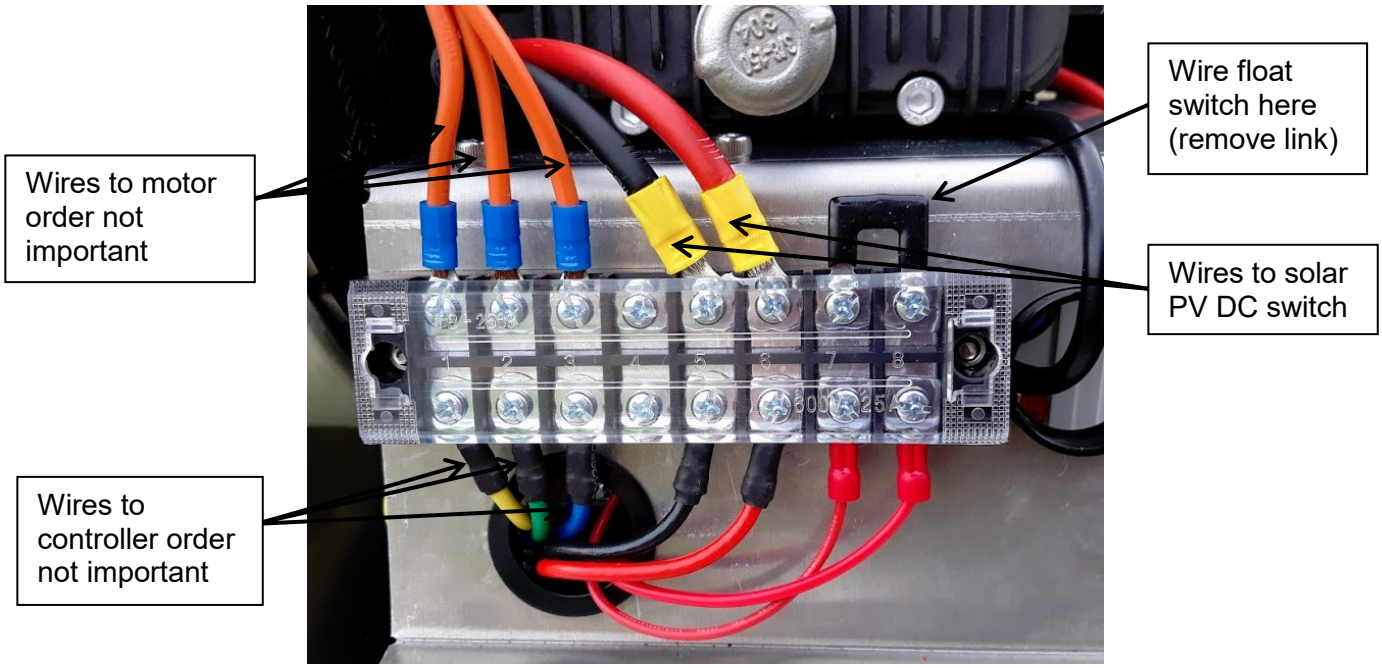


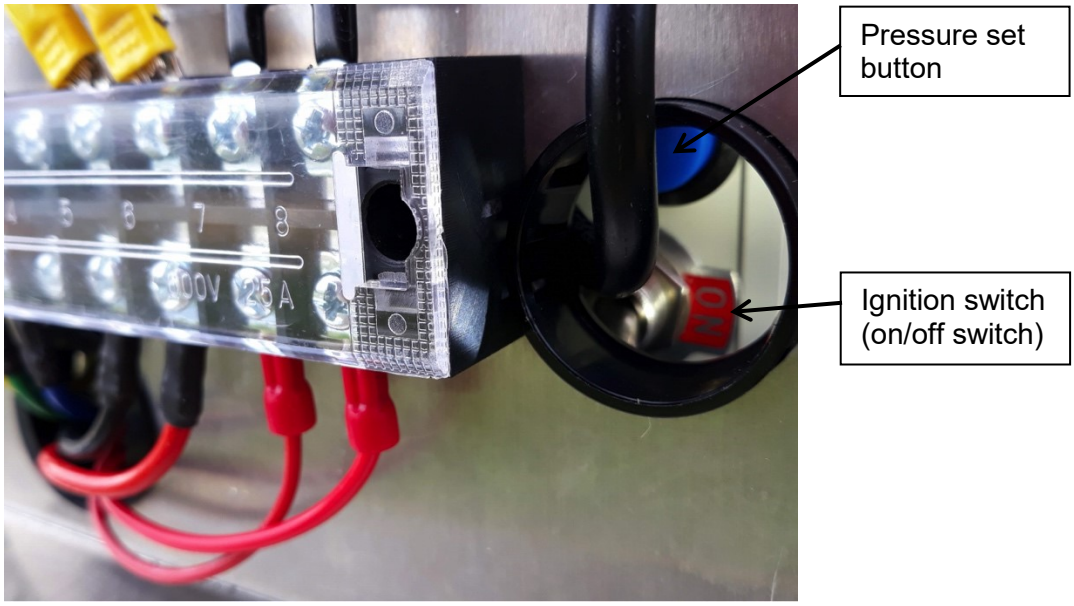
View of wiring connections

2.1.6. LED indicator

- Green solid – pump is running.
- Green blinking – pump waiting, there is insufficient solar power to start pumping will try again in 30 seconds.
- Blue solid (for 5s) – pressure limit successfully set.
- Blue blinking – pump waiting, the pressure sensor has activated, will try to start again in 30 minutes.
- Clear (no light) – ignition switch is off or DC switch is off or float sensor has activated or it is night time.
- Red blinking - memory error, please reset the pressure limit.
- Red solid – for up to 5 seconds Voc/MPPT check in progress, this is done every 10 minutes.

2.1.7. Wiring detail





2.1.8. Rodent guard (customers required to cut to fit as shown)

2.1.9. Smart Drive motor

The magnetic rotor (black or beige) is mounted on the pump shaft. The stator is stationary. There are no wearing parts – no brushes or separate bearings.

2.1.10. SHP (Pontoon)

2.2. SHP-Triplex pump performance

See the back of this manual for a brief summary of specifications.

These tables are given as a guide only for typical NZ conditions. The test site where this data was measured was in Taranaki NZ. Places with higher average solar radiation levels will observe higher litres per day pumped and vice-versa.

2.2.1. Summer flow volumes (litres per day)

Table of flow in L/day

When	PV array size	Pumping head 50m	100m	150m	200m	250m	300m
Best summers day	1080 W due North	9584	8685	7810	7028	6299	5575
Cloudy summers day	1080 W due North	4792	3884	3076	2530	2079	1728
Best summers day	1080 W split East/West	11980	10856	9763	8784	7874	6968
Cloudy summers day	1080 W split East/West	4792	3884	3076	2530	2079	1728
Best summers day	540 W due North	6825	5645	4508	N/A	N/A	N/A
Cloudy summers day	540 W due North	3889	2935	2081	N/A	N/A	N/A

Data collected in early Jan 2019

2.2.2. Estimated flow per day over the calendar year

1080W solar PV installed (540W East and 540W West)

Month	Head (m) <50m	100	150	200	250	300
December	8439	7378	6390	5610	4918	4287
January	8985	7855	6804	5973	5236	4564
February	8879	7763	6724	5903	5174	4510
March	8054	7041	6099	5354	4694	4091
April	6093	5327	4614	4051	3551	3095
May	4816	4211	3647	3202	2807	2446
June	3955	3458	2995	2629	2305	2009
July	4835	4227	3662	3215	2818	2456
August	5838	5104	4421	3881	3402	2966
September	6745	5897	5108	4484	3931	3427
October	7602	6646	5756	5054	4430	3862
November	8287	7246	6276	5510	4830	4210

For example: here on our test site, on a typical summer's day, we can expect about 6800 l/day to a 150m dynamic head. (120m vertical lift + 30m pipe friction head).

This table may over predict or under predict for your NZ location; it is indicative only. As more data comes in from our test sites these number will be further refined. If you live in a blue sky desert (like many parts of Australia) then performance will be higher. If your chosen pipe diameter results in a very high friction head then you will get a little less.

The pump will work fine on heads as low as 10m, where it will run most of the time at full speed and peak flow rate. **For heads below 50m where less flow is needed, consider fitting only 540W of solar PV facing midday sun**. With this array size you will still pump about 2/3 of the flow indicated above. On your best summers day it is possible to pump up to 12,000 litres on a 1080W PV array on heads below 50m. Below 50m less power is required so the pump spends more time running at full speed, limited by the electronic BLDC speed controller to 1200 rpm.

It is our view that most of our NZ customers will wish to pump in the 50-160m static head range and so our advice is to install a 1080W PV array with 540W facing East and 540W facing West.

2.2.3. Maximum flow rate possible at each head

Head	Peak L/min
50	15.79
100	15.24
150	14.56
200	13.81
250	13.10
300	12.40

This maximum (peak) flow of the pump (see right) can be a little misleading and should not be used to calculate daily water quantities. What is more useful is the average flow per day over the calendar year as listed in the previous table.

The peak flow figure is needed (as you will see later) when determining the size of pipe from the SHP-Triplex to your header tank.

Our competition also publishes these peak flow figures for the same reason (and often little else). It is easy to measure the maximum flow yourself (in conditions of full sun at right angles to the solar array) so you can verify from a simple test that all is working correctly. As you can see, peak flows for the SHP-Triplex do not fall much with increasing head. This is because as the head increases more of the solar PV power can be utilized and the pump efficiency is also higher at higher heads.

2.2.4. Peak pump efficiency

SHP-Triplex efficiency increases steadily with head. Efficiency is best when:

- RPM is lower.
- Pump is highly loaded.
- Incoming solar radiation is not at its peak. (Peak PV power is more than can be used whereas morning, afternoon and cloudy periods provide usable power.)

Head	Peak L/min	Peak Efficiency %	Efficiency % at peak flow
50	15.79	32	26
100	15.24	47	40
150	14.56	56	50
200	13.81	61	57
250	13.10	65	61
300	12.40	67	64

2.2.5. Solar PV utilisation efficiency

Solar PV utilsation efficiency is the power consumed by the SHP-Triplex at midday on a clear summers day divided by the nominal PV array size in "W_P".

Head	Peak L/min	Peak Efficiency %	540W Ulitization eff at midday	1080W Ulitization eff at midday
50	15.79	32	89	48
100	15.24	47	89	57
150	14.56	56	89	67
200	13.81	61	89	74
250	13.10	65	89	81
300	12.40	67	89	88

The table illustrates that the power available from a smaller PV array is better utilized. This means that there comes a point (at midday on a sunny summers day) where more installed PV will not result in more pumped water. There is a diminishing return for every extra 540W of PV installed. The implications of this are discussed in more detail in section 7.

2.2.6. Maximum input power of SHP at various heads

Head (m)	Max Power SHP can use (Watts)
50	510
100	620
150	720
200	805
250	880
300	945

As shown opposite, installing more than 540W of PV will not result in significantly higher peak pumping rates on very sunny days, but more solar PV is needed on higher head sites to ensure reliable starting of the SHP-Triplex.

A larger PV array will increase the hours of operation in less ideal weather and extend the operating day length and the amount of pumped water. See section 2.2.9 for recommend PV array size.

2.2.7. Pumping Height of the PowerSpout SHP

The PowerSpout SHP has a maximum ***dynamic*** pumping head of 300 m (1000 feet). (But keep in mind that 160m (aka 16bar) is the upper limit of common HDPE farm pipes.)

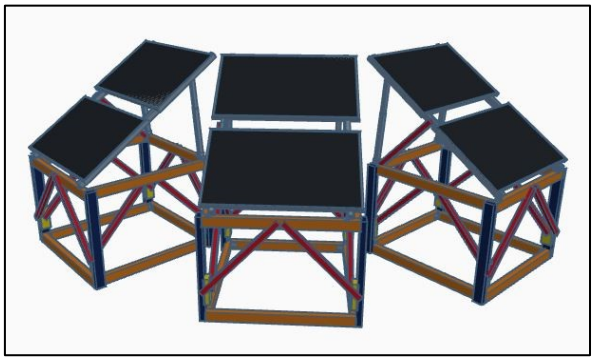
If you have a specialized application and want to pump up to 500m head, we can also do this but need to fit a lower RPM higher power motor. We can do this but the retail price will be at least twice the standard price for a specially made SHP-Triplex to order.

2.2.8. Seasonal Variation

The SHP delivered flow will change throughout the year with sunlight intensity but this tends to be a good match to demand. In general, farm animals drink much more water from troughs on sunny days than wet overcast days. A solar PV powered pump is a very good choice to meet stock water needs.

The SHP is intended for cattle and sheep farms where water demand peaks with sunlight intensity. Farmers who intend to use an SHP for the water supply for dairy cows milking in winter need to check winter radiation levels carefully in selecting the optimum number of SHP's required.

Such farms should install 1620W (or the maximum 2160W we allow) of solar PV per SHP to lift winter pumping yield. Three arrays increases nominal solar wattage from 1080 to 1,620W, which will not increase the maximum pumping rate but will extend the operating hours in marginal weather or conditions/seasons. Or consider using a backup pump or a backup power source for your SHP at these marginal times.



2.2.9. Recommended PV array size

Dynamic Head	Nominal PV array size	SHP-Triplex
<50m	540W or 1080W	Standard version
>50m < 160m	1080W or 1620W	Standard version
>160m < 300m	1620W	High torque version (surcharge applies)
>3000 <500m	1620W or larger	Specially made to order high torque and slow speed (surcharge applies)

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2.3. Step by step design overview

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

You will need to do the following:

- Consider whether a single SHP is likely to meet your L/day needs before you commit to purchase. (If you are unsure of your needs, you can always install one and see how you go before deciding to buy a second unit.)
- Install a suitably sized header tank if you do not have one already.
- Install a correctly sized pipe from your SHP to your header tank (typically 20 or 25mm NB (nominal bore) PE pipe.
- Install the PV array in a sunny location within 100m of the SHP.
- Install the wiring between the SHP and the PV array.
- Commission the system.

All the above should take 2-3 days work for a competent person.

2.3.1. PowerSpout SHP site data requirements

As we only make one version of the SHP-Triplex, and as it will pump in the range 10-300m head we need no site information from you prior to purchase. But you do need to survey the site to establish the pipe size, pressure rating and length and to get an initial estimate of the pumped volume per day that you can expect to reach the storage tank.

2.3.2. Measuring head

You will need to measure the vertical rise in feet or metres (referred to as head or lift). Altimeter, GPS, Smart Phone app or Google Earth - not very accurate but it will give you a rough indication of the head and pipe length.

2.3.3. Measuring flow in your water resource

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.

As a small flowing water resource is required a 1-10 litre bucket will be sufficient.

If the flow rate is not enough to keep up with your SHP (see table opposite) then you may want to consider a storage pond that fills with water overnight. In order to be useful this must hold at least 5 cubic metres of water (5000 litres) per SHP. If half a metre deep on average, this would be a pond with area 10 square metres.

Head	Peak L/min
50	15.79
100	15.24
150	14.56
200	13.81
250	13.10
300	12.40

2.3.4. Choosing the correct number of SHPs for your site

Different sites will need a different number PowerSpout SHPs depending on the head and daily volume you need to pump. It is not an economic option to manufacture many different SHP pump size options. If you need more flow or more head all you need to do is install another SHP.

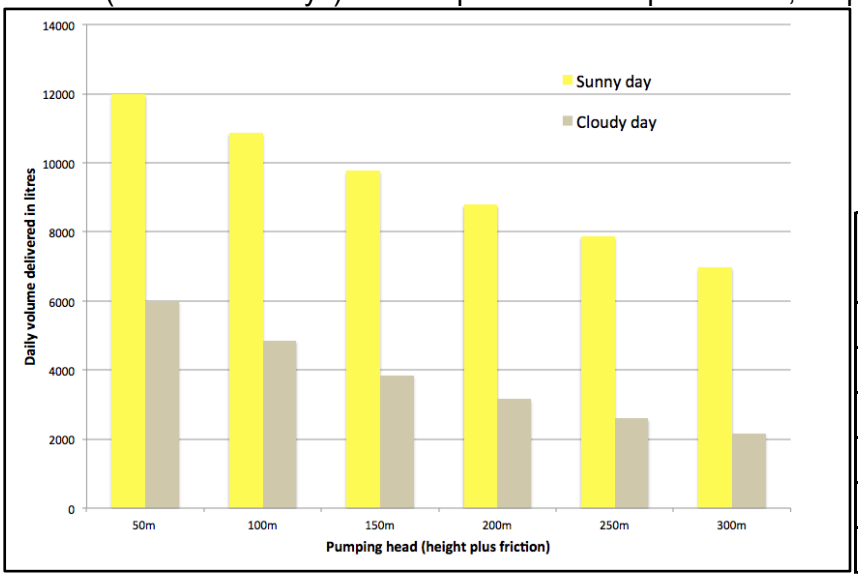
More than one SHP greatly improves system reliability on parallel installations, as if you do get an SHP failure (solar PV panels rarely fail as they have no moving parts), then up to 1620W of the available solar PV can be attached to the remaining SHP while the other unit is away being repaired.

Repairs when needed are simple and fast. You can either send it back by courier to EcoInnovation (only NZ clients) or you can do it yourself by buying the parts you need online.

With multiple pumps you could simply run the SHPs until one fails rather than having to take a more proactive approach with annual maintenance checks.

With many water source combinations, 3 x PV array sizes, multiple SHPs, parallel and series installations the SHP can solve almost any stock water pumping problem.

Once you have determined the head, use this chart and table to estimate your daily pumped volume (for summer days) and the peak flow rate per turbine, for pipe sizing.



Head	Peak L/min
50	15.79
100	15.24
150	14.56
200	13.81
250	13.10
300	12.40

These estimates are based on performance measured at our test site in Taranaki NZ. We regard this data as indicative of likely performance – you may pump more or less than this.

- If for example you need 7,500 l/day in summer to a 100m tank you will need to install one SHP with pipes rated for 12 bar.
- If for example you need 15,000 l/day in summer to a 100m tank you will need to install two SHPs in parallel with a larger pipe rated for 12 bar.
- If for example you need 5,000 l/day in summer to a 200m tank you will need to install one SHP with pipes rate for 20 bar.
- If for example you need 6,000 l/day in summer to a 320m tank you will need to install two SHPs in series with pipes rated for 16 bar.
- If for example you need 5,000 l/day in summer to a 750m tank you will need to install three SHPs in series with pipes rated for 25 bar.

2.3.5. Matching the SHP supply to demand changes

Matching the supply of the pump to your demands is achieved by adequately sizing your storage tank. Bigger is always better. The amount of water pumped will change with the available sunlight but this will normally also mirror your demands.

2.3.6. Incrementally increasing the system size cost to meet your needs

Let's assume you are a farmer with a moderate sized herd and need a water supply on the back hilly part of the farm. There is no utility/mains power available. Water had previously been provided by access to a stream and small man-made pond. This practice is no longer acceptable due to the new fencing requirement to help reduce water pollution from large farm animals. You also want to fence into paddocks the large hill block, so gains can be made from improved stock & pasture management.

You are very busy, have only $3-4000NZ to spend on the pump and PV array. You do not want to waste any more time trying to accurately determine how much water you will need each season as you need the problem mostly solved immediately. Fencing work is about to start and that means water for paddock troughs is needed urgently. Your gut feeling based on decades of farming experience is that 5,000-10,000 L/day in summer should do it. Google Earth indicates the hill is about 50-70m high (above pond level).

In this case the farmer can:

- Start off by installing a minimum package of one SHP-Triplex and 540W of PV on a pontoon on his pond or on the adjacent land.
- If more litres/day are needed later, the PV array size can be doubled at this later date.
- If still more litres/day are needed (mainly on hot clear summer days) the array can be configured East/West.
- If still more flow is needed another SHP can be installed with 540W of PV per SHP.
- If still more flow is needed the second SHP can have another 540W of PV added.
- If still more litres/day are needed (mainly on hot clear summer days) the arrays can both be configured East/West.
- If still more flow is needed on overcast days or in winter time each SHP can have up to 1620W of solar PV added.

The above example illustrates that you can take a "watch and see approach" if you are unsure of your pumping needs, or if your demand grows in the future. The farmer will need to consider whether the original delivery pipe is large enough and it may need to be upgraded or additional pipe(s) installed as the system is upgraded.

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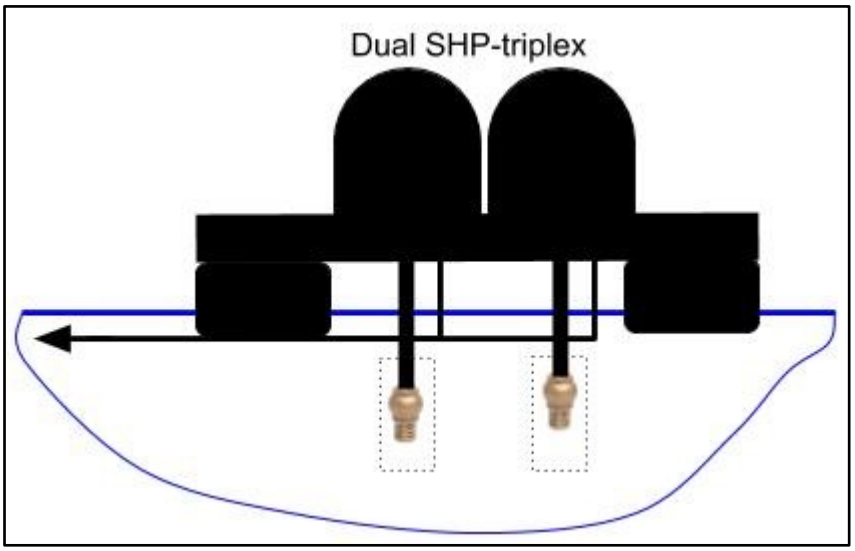
2.4. Multiple SHP-Triplex install examples

2.4.1. Higher flow parallel installation

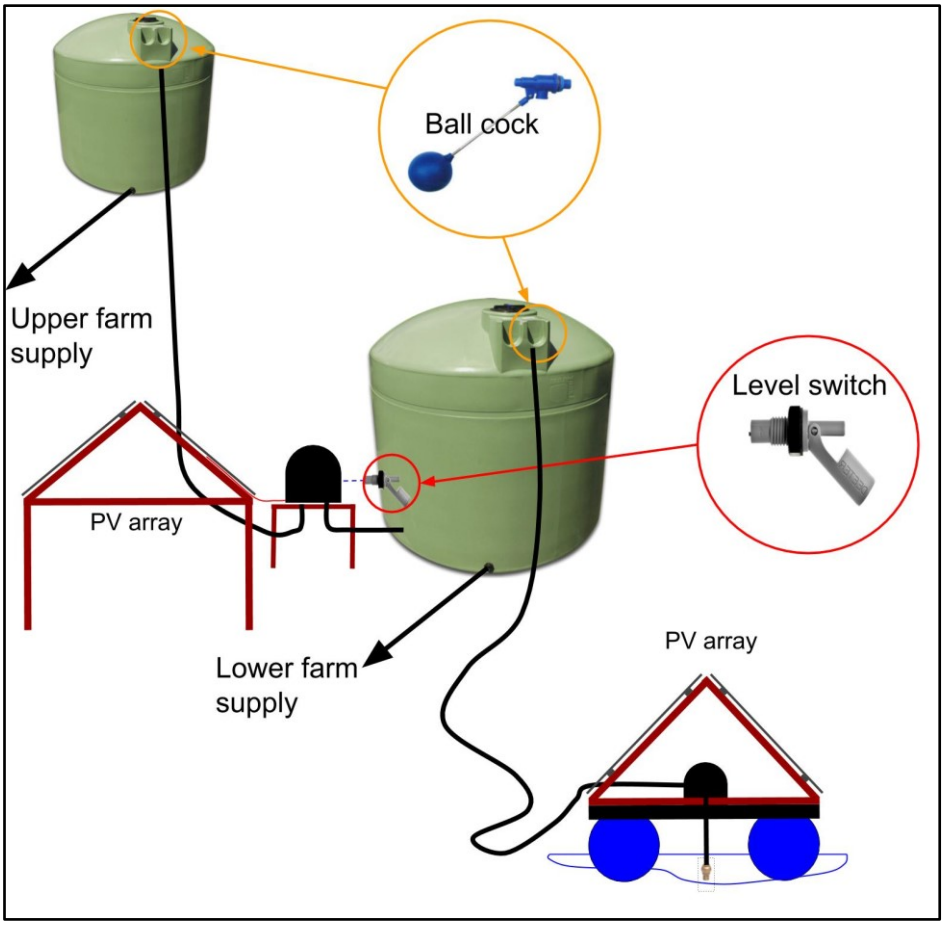


Multiple pumps can be connected to the same delivery pipe to increase your flow.

2.4.2. High head series installations

A series installation is where one pump feeds another one half way up the slope.

Series installations are more reliable than one SHP as if the lower SHP fails the upper can be moved to the lower position so that at least the lower part of the farm has water.

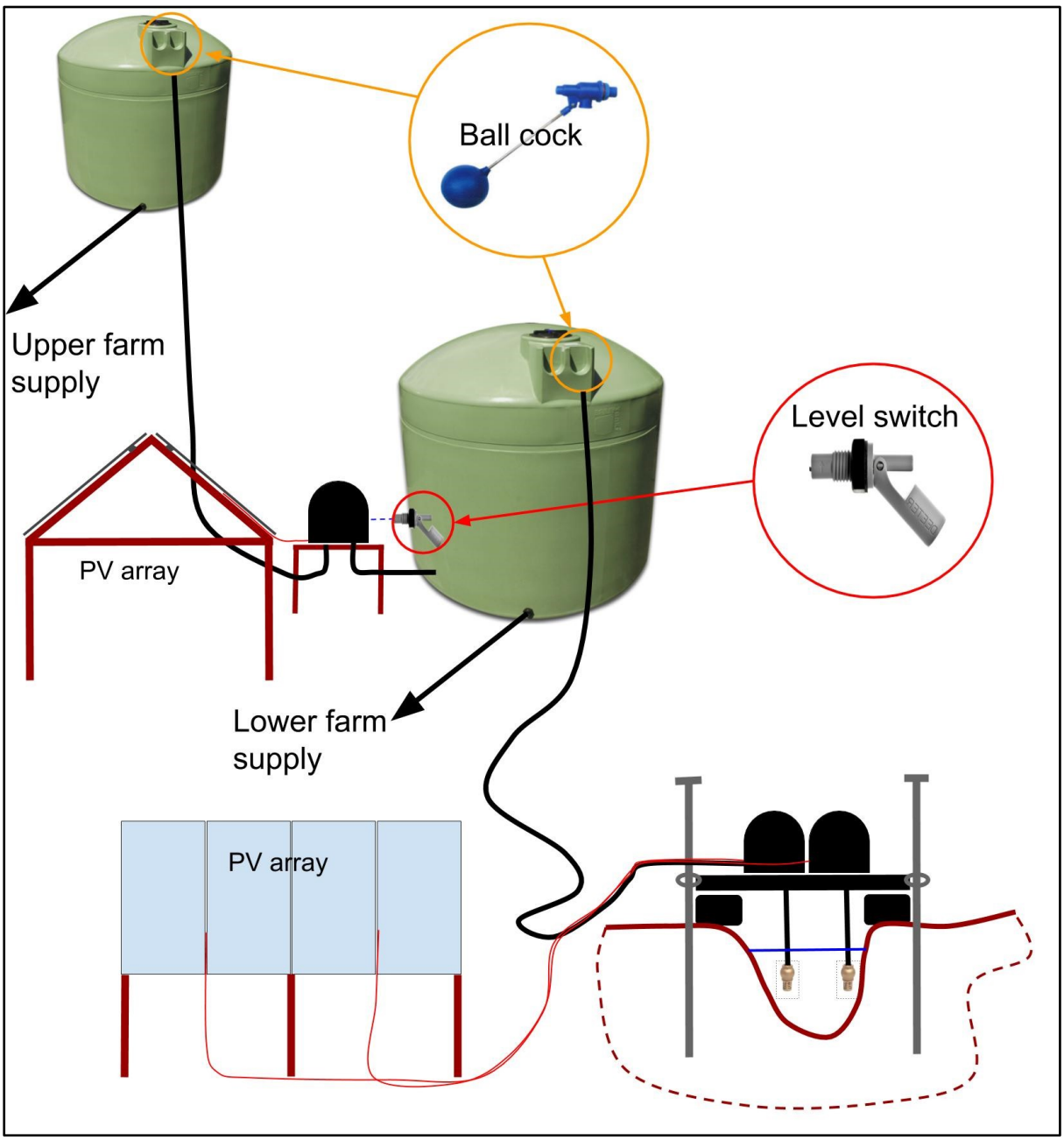


2.4.3. High flow twin SHP to lower farm, high head series SHP to upper farm

If you decide to pump all the water to a tank on the highest hill (so as to supply all troughs below) this point then you need to think carefully on these points:

- You may require more costly pipes or a pressure reducer to prevent pipes from bursting at lower locations due to the high pressure.
- If most water on the farm is consumed at the lower troughs, then pumping all the water to the highest point is a less efficient use of your pumping infrastructure.

The illustration that follows for farms with high heads (typically 160-500m) can work well. Up to twice as much water is available on the lower part of the farm than the higher smaller part of the farm.



2.5. Effects of having not enough water for the SHP

The flow of water through the SHP depends on having water in your resource. If your resource flow cannot keep up with the SHP pumped flow then the level will fall until air enters the suction line. A small buffer pond in the water resource can store the water that flows during the night when the SHP cannot run.

Once air enters the SHP it will continue to rotate, but no water can be pumped, as suction prime will have been lost. This can damage the SHP as it needs water to cool and lubricate it. Our software team are working on a sensor (future upgrade) that will stop the pump if this condition is observed). Allowing the SHP to run without water will cause about $100 worth of parts damage. So it is not a major issue, but should be avoided with the addition of a level switch.

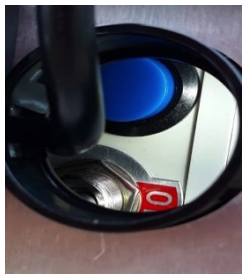
Also, once air enters your suction line you will need to manually prime it. If the supply pipe to the header tanks is full of water, then you will need to manually open the bypass valve while running the pump so that the air lock can clear.

To avoid both of the above issues, fit a float stop switch to stop the SHP if the level ever gets too low. We supply a float switch (optional extra), and there are contacts on the controller for a float switch.

2.6. Pumping too much water and conserving your water resource

Your SHP may pump more water than you need at times, your SHP is fitted with a pressure transducer which will turn the SHP off at a pressure you can set via a button.

When you start your SHP-Triplex for the first time, the long supply pipe to your tank will start to fill. Depending on factors such as head, solar radiation, length and size of the supply pipe it may take up to 30 minutes or more before your storage tanks will start to fill. While the pipe is filling you can walk the line slowly and check for any leaks.



2.6.1. Setting the off-pressure

Once you can hear that water is entering the tank, return to the SHP and press the button on the SHP (shown opposite) and watch the LED (refer to 2.1.6).

This action sets the off-pressure to the measured pressure at that moment. The allowance added to the measured pressure is the greater of 20m or 20%. You cannot set the off-pressure to >300m. You cannot set the off-pressure to < 60m (6 bar pipe grade are higher rated must always be installed).

Then when the tank is full and the ball cock starts to close, the pressure will rise and the pump will turn off for 30 minutes before attempting to restart.

2.6.2. Resetting the off-pressure

If you accidentally press the button at the wrong time or wish to reset the off-pressure (or after changes to your system) you can follow this procedure below to reset the off-pressure. To disable the user set off-pressure (which then defaults to 300m):

- Ensure the PV main DC switch is on.
- Turn off the BLDC via the ignition switch (if off already leave it off).
- Press the button (Blue LED will stay on for 5 seconds).
- Turn on the BLDC via the ignition switch.

You can now repeat the setting procedure in section 2.6.1

2.6.3. If you fail to set the off-pressure

If you fail to set the off-pressure and have a ball cock fitted in your tank the pump will keep going until your pipe bursts or 300m head is reached. This is why we advise the installation of a weak link as detailed next. This also protects your pipe in the event of a pressure sensor failure.

Warning

If you disable the pressure sensor (or fail to commission your SHP and check correct operation) and a ball cock is fitted in your tank, the SHP will probably rupture the pipe. This will not normally (see below) harm the pump; it will increase in speed and keep pumping water through the hole in the burst pipe.

It is inevitable that some installers and owners will do just this, we suggest you weaken your pipe (or use a short length of lower pressure rated pipe) just after the SHP in a section of the pipe that is easy to access with a pipe joiner on either side of the weakened section. (Ensure this section is on land if your SHP is pontoon mounted.) You do not want the pipe to rupture at the SHP outlet fitting (where the pressure is greatest) as this could spray water all over the internal workings of the SHP and cause serious damage.

You can weaken the pipe by filing a flat on the top of the pipe plastic with a file, it will then fail at this point should the pipe be exposed to excessive pressures.

File a few samples, if one bursts while pumping normally take less off next time.

2.7. Supply water to top or bottom of storage tank

You have the option to connect the supply pipe from the SHP-Triplex to either the top or the bottom of the storage tank. These are some considerations.

Top connection:

- Easy to fit a ball valve.
- Silt can settle out in the large storage tank where it can be easily syphoned out every few years.
- If the supply pipe is damaged and leaks the water in the tank is not lost to the leak.
- If the supply pipe is used to feed troughs on the way to the tank (this can be a saving in pipe quantity needed), then these troughs will have a limited supply from the SHP-Triplex (no night time supply) combined with limited pipe storage.

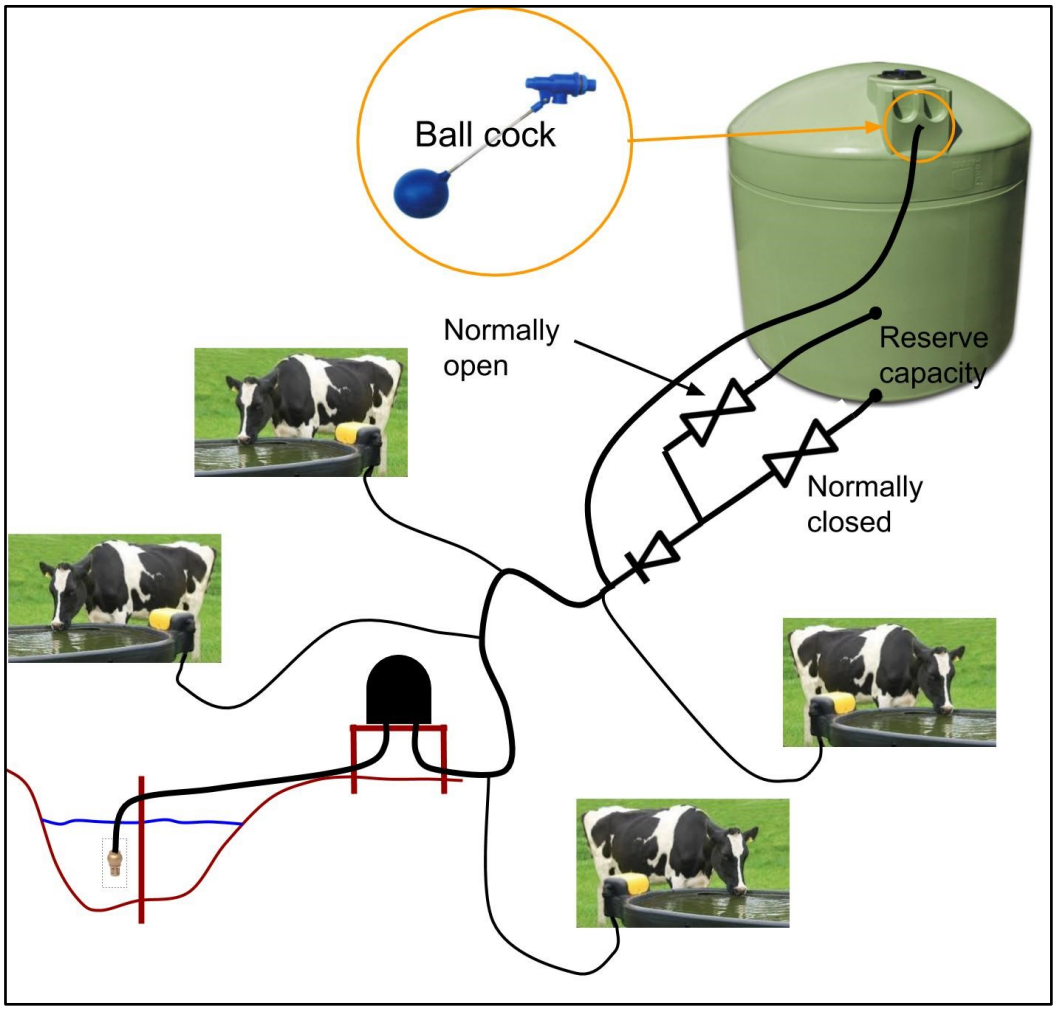
Bottom connection:

- Float for the ball valve must be on a rope, such a ball valve is difficult to access as you have to get inside the tank to install and maintain it. Working in a confined space can be dangerous, legislation applies.
- If the supply pipe is damaged, water in the tank is lost to the leak.
- The supply pipe can be used to feed troughs on the way to the tank.

In general, it is more common to top feed the supply tank. Pipe outlets about 1/3 of the way up the tank can give reserve capacity in the event that any pipe in the system is damaged and leaks. A compromise, such as a middle connection may be a good option for some farmers to consider if reserve capacity is critical to the farming operation.

Advised connection (a compromise of top and bottom options):

- Easy to fit a ball valve.
- Silt can settle out in the large storage tank where it can be easily syphoned out every few years.
- If the supply pipe is damaged and leaks all the water in the tank **is not** lost to the leak as you have a reserve capacity.
- The supply pipe can be used to feed troughs on the way to the tank.



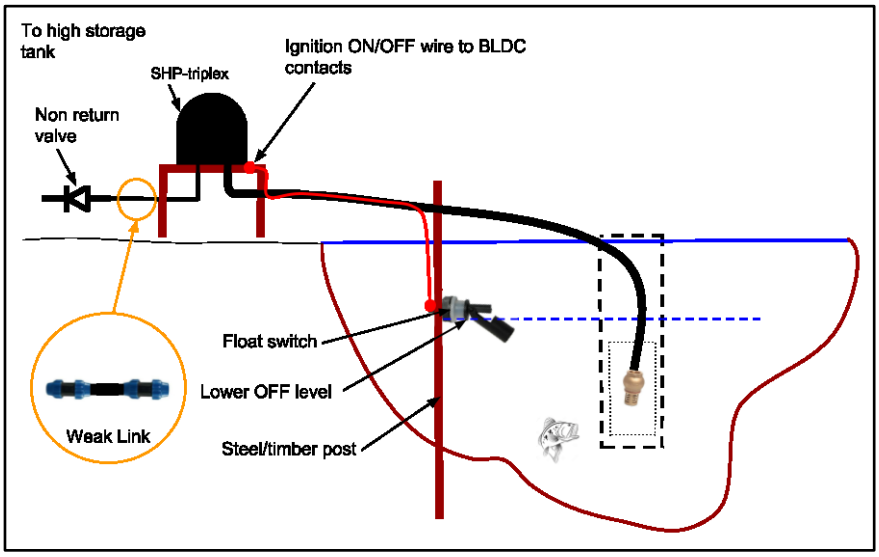
2.7.1. Overflow pipe

If you do not intend to use the pressure sensor to turn the pump off then we suggest that you install a return pipe on the tank overflow fitting. This is the simplest option for dealing with surplus water. If you have previously used grid electricity or a fuel pump you would normally stop the pump when the water tank is full to save running costs. You do not need to do this with a solar pump as sunlight is free. There is more wear and tear on the pump if you let it run when it is not needed, this is an extra cost in maintenance. Farmers who require all the water that can be pumped or those with lower pressure rated pipes may opt for this option.

2.7.2. Conserving your resource

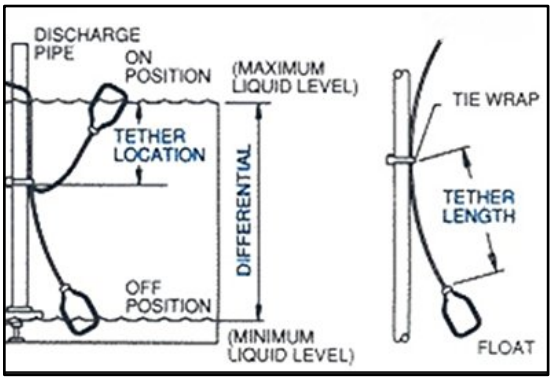
There will be occasions when your resource may run dry or the pumping rate exceeds the natural flow rate of the resource. In such cases you either need to stop pumping or provide a pumping buffer (tank or pond) for the resource to accumulate when the SHP cannot pump.

If for example you have a small spring with a dry summer flow of 0.1 l/s (10s to fill a 1 litre container) then in a day this is 9000 litres and a very helpful amount on a dry sheep/cattle farm. If we assume you need all this water to be pumped to your tank on a 60m hill each day, then some buffer storage of the water resource is required. Normally this storage would naturally replenish at night when your SHP cannot operate.



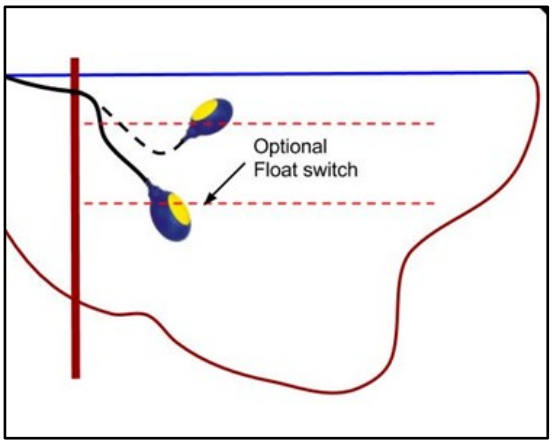
To stop the SHP a float switch can be wired to the BLDC driver's "ignition" contact. (Do not install a switch on the PV supply wires).

This solution will stop the pump at the lowest acceptable level of your water intake resource.



Floating switches that are tethered by their own wire can provide a wide, adjustable hysteresis between turning on and off. Much of the time they float level on the water surface. The switch will not operate until it tilts.

If the small spring can be diverted into a pipe and fed by gravity into a 10-15,000 litre tank then the outlet of tank can be connected to the input of your SHP, and is the best solution.



If you do not have the fall for a tank, you can excavate a small pond to store about 20,000 litres. Ponds can be a death trap for children and animals, so fence it appropriately.

Then you can install an SHP on a small pontoon in the middle of your pond with the suction hose set about 200mm below the surface where UV from the sun helps to sterilise the water being pumped. Design the pontoon structure to sit on the bottom of the pond before the foot valve intake hits the mud/silt level and where the SHP turns off.

2.8. Dealing with dirty water

No farmer wants to pump dirty water, as this dirt will foul pipes, tanks and troughs resulting in more work at some future date to clean it all out.

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2.8.1. Our advice for moderately clean water resources:

- Each SHP comes with an intake foot valve strainer and replaceable intake filter sock. It is fouls too quickly install a much larger stainless wire basket and filter sock.
- Ensure you have good access so that you can easily lift out the foot valve and replace the sock as needed and to check that the foot valve is always in perfect working order.

2.8.2. Our advice for rather dirty water resources:

- Provide a small pond where possible so that your water resource has more time to settle. Ensure you have a large flush pipe and valve in the bottom of your pond so you can flush silt away, otherwise your pond will soon silt up and be difficult to clean out.
- Ensure you have good access so that you can easily lift out the foot valve and replace the sock as needed and to check that the foot valve is always in perfect working order. See the operation section at the end of the manual.

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3. Solar array design and installation

3.1. Understanding PV size and orientation

The size of solar PV array you need to install depends on the head, the amount of water you wish to pump, your budget and our advice. There are many possible solutions. You can use any make of monocrystalline or polycrystalline panel so long as the open circuit voltage per panel is <40VDC and the voltage for peak power is >30 VDC. They must be wired in pairs. You can fit 2, 4, or 6 panels, depending on your head and pumping volume required. PV panel's are all the same physical size, nominally 1m wide x 1.65m long, but their Nominal Power - (P_{MPP} in Watts) can range from 240W_p to 300W_p per panel. Our installations examples (that follow) use 270W panels as these were the most cost effective at the time of writing.

The solar panels power the BLDC driver that in turn powers the pump motor. The BLDC driver takes power from the solar array with a Vmp in the range 58-64V approx. (and Voc not exceeding 80V). The pump will stop and start in marginal conditions. It needs a minimum of 100-200W of actual solar power to operate, and it uses a maximum of 900W (at higher heads). How much power is available depends on the brightness of the sunshine and the number of solar panels. We recommend using two solar arrays per SHP, each approximately 540W. Each array normally comprises two standard solar panels connected in series.

The pump will slow every so often so that the microprocessor can measure the Voc to obtain the maximum power point voltage Vmp. Vmp = 0.8 x Voc. The rpm of the pump is then continuously adjusted to ensure it runs at the Vmp until the next check (typically every 10 minutes).

The comments that follow focus mainly on pumping water in the head range 30-160m with a 1080W PV array, with a focus on summer time flow, as most farmers will need this type of system.

3.1.1. Single array facing midday sun

In NZ (southern hemisphere) the midday sun is due north between 1 and 1:30 PM rising at about 6 AM and setting at about 9 PM). An array facing north will not be able to power the SHP-Triplex until about 8 AM, and it will stop at about 7 PM. This is because close to sunrise and sunset the sun is behind or edge-on to the solar array and low in the sky so less solar radiation is available to be harnessed at these times.

We also have to consider that the SHP-Triplex at heads below 160m cannot use more than 750W of power despite up to 1080W being nominally available from a north facing array at times close to midday sun. This 1080W PV array is chosen because it will only generate this peak power for a short time in full sun around midday which is not a long time. There will be clouds much of the time in reality. Higher midday temperatures mean that a 1080W PV array may never generate more than 900W (as solar panels are less efficient at high temperatures).

There is no value in producing a very high peak output at midday, so do not orient the arrays to both face due north (or south in the northern hemisphere). The important consideration is to extend the operating hours by starting the pump earlier in the day, and keeping it running later in the day.

3.1.2. Array split into two halves facing East and West

If the installation site is not shaded by hills, trees or buildings from morning and evening sun and we want to pump longer and have more power available sooner it makes sense to have an array split into East and West facing halves. The SHP-Triplex would then start pumping at about 6:30 AM and stop at 8:30 PM.

Pumping power at midday will not be affected, as with the sun directly overhead the 1080W East/West array will still be able to deliver the power needed for the pump to be at full power capacity.

On an overcast summer's day the light is diffused by the clouds. So on a cloudy day both arrays will generate to a similar extent regardless of where the sun actually is. We may never generate more than 300W from the 1080W array on a heavy grey summers day in NZ, but all this 300W can be used, so the pumping yield does not suffer as much as you might expect.

Winter sun is never directly overhead unless you are close to the equator. The angle of an East/West array should be biased to morning, evening and winter sun. 45 degrees is a good angle for and East/West array. Visualize a roof with a 45 degree pitch facing East and West and you have it. The 4 x 270W panels are then very easy to mount onto a simple truss that is described in more detail later. Such a truss can be mounted on 4 posts in the ground or on a pontoon floating of your water resource.

In summary an East/West array pitched at 45 degrees will yield:

- more pumped water on a sunny day
- more pumped water on an overcast day
- better all day and all year production if pitched at about 45 degrees

3.1.3. Sites with shading in the morning and/or evening

Where the site does not benefit from early sun in the morning, and/or late sun in the evening due to shading, the optimum arrangement will be to point the sub-arrays at the mid-morning and mid-afternoon sun as shown here.

3.1.4. Smaller PV array orientation

If your pumping needs are modest and mainly summer biased then a smaller 2-panel PV array of 540W may be sufficient. This array size must be pointed at midday sun at a pitch of 20-30 degrees. Or point it in the middle of the shade free time-zone if your site is clipped by shading from surrounding features. (Do not face the two panels in different directions as they must work together in series as a pair.)

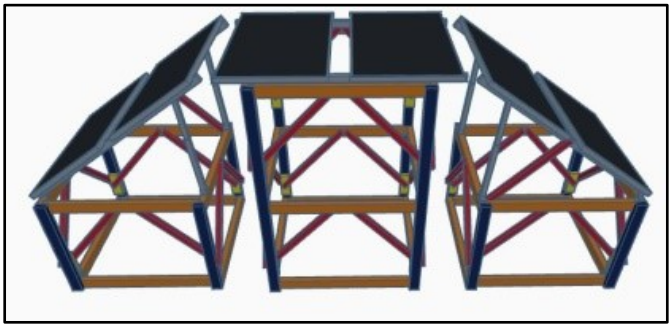
540W PV - facing midday sun (10-50m head)

3.1.5. Larger PV array for maximising pumped volume in winter or poor weather conditions.

On cloudy sites or where more water is desired it can be helpful to add a third array, bringing the total "rated" power to approximately 1,620W, but the pump will never use more than 900W. This third array will enhance performance and extend operating hours in marginal sunlight conditions. In some cases there will be a need to add string fuses to the wiring when a third array is connected.

3.1.6. 1620W PV - facing morning, midday and evening sun (160-300m head) in the shade free zone

For sites close to the equator (and sites using a truss frame – discussed later) we advise one pair due East one pair due West. The third pair is positioned completely flat between these two as shown.
There will usually be a need to add string fuses to the wiring when a fourth array is connected. (see 3.2.3)



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3.2. Wiring the PV to the SHP

The SHP comes with two MC4 type connectors on flying leads. Mating MC4 plugs of the same (or compatible) brand are supplied.

In NZ we can supply solar PV wire from the Solar PV array switch box to the SHP (normally 4mm^2 tinned double insulated). It all arrives ready to plug together, but you must advise the wire length required. If the distance is long then you may need to double the size of the wire used, and beyond 100m you may need to install larger aluminium wire.

Cable length (m)	4mm^2 650W % loss	8mm^2 650W % loss	25mm^2 650W % loss	$NZ cost to supply	Material	Wire protection
10	1.5			40	Tinned copper 2 cores	20mm LDPE/PVC
20	3.0			80	Tinned copper 2 cores	20mm LDPE/PVC
30	4.5			120	Tinned copper 2 cores	20mm LDPE/PVC
40	6.0			160	Tinned copper 2 cores	20mm LDPE/PVC
50	7.5			200	Tinned copper 2 cores	20mm LDPE/PVC
60		4.0		480	Tinned copper 4 cores	25mm LDPE/PVC
70		5.0		560	Tinned copper 4 cores	25mm LDPE/PVC
80		6.0		640	Tinned copper 4 cores	25mm LDPE/PVC
90		7.0		720	Tinned copper 4 cores	25mm LDPE/PVC
100		8.0		800	Tinned copper 4 cores	25mm LDPE/PVC
125			5	400	Aluminmu 2-core	25mm LDPE/PVC
250			10	800	Aluminmu 2-core	25mm LDPE/PVC
Costs are approx. based on 2017 prices and exclude GST and freight						

The table above indicates the percentage power loss at 650W pump power. Cable runs less than 30m are typical and are a very cost effective solution. Longer cable runs should be avoided where possible. Try to keep cable losses under 5% loss (some countries mandate only up to 3% loss), the power cables are low cost compared to the long delivery pipe (pipe typically has 10-30% loss at rated flow).

The SEIDP guideline states that: "Under maximum load conditions the voltage drop from the most remote module in the array to the input of the controller should not exceed 3% of the maximum power point voltage (V_{mp} at Standard Test Conditions) of the array.". To comply with this guideline larger cables than stated above may need to be installed.

3.2.1. ELV Wire protection

In NZ and Australia ELV wire protection is covered in:

- AS NZS 5033
- AS NZS 3000
- AS NZS 4509

At the time of writing (for NZ) these are the rules for ELV wiring:

> 5033: 7.5.11.3 Underground conductors. There are no depth-of-burial requirements for the safety of extra-low voltage cables. NOTE: Consideration should be given to the risk of mechanical damage.

The above means that in NZ ELV cables that lay in contact with the ground do not need to be buried and can be laid *on the ground*, only “Consideration” needs to be given to protection of the cable, for example from:

- UV radiation (sleeve in LDPE pipe).

- Cattle hoofs (sleeve in LDPE pipe).
- Cattle teeth (sleeve in LDPE pipe).
- Tractors and farm bikes (Sleeve in LDPE pipe and bury 100mm down at gate/track crossings).

3.2.2. Over current wire protection

In most (cases but see 3.2.3), no over-current protection is required, as (unlike the case with a battery or grid connected system) the short circuit current is limited to the "Isc" the PV panels can produce. Here are typical values:

- 18amps (1060 W PV).
- 27amp (1620 W PV).

These currents cannot therefore overload the MC4 connectors and 4mm^2 wiring that is rated for 30 amps.

For clients who want to add a larger array, this is possible provided a DC breaker rated for 30 amps is installed to replace the DC switch. (String fuses will likely also be required, see 3.2.3 below.)

We supply with every SHP a DC switch to allow the system to be turned on/off. This switch is a convenient DC on/off switch, which can be opened without damage under full load current. This switch is required to be labelled to identify its use and purpose.

We supply the switch (with a new SHP purchase) already labelled for you.

3.2.3. "Maximum Series Fuse" rating and the possible need for string fuses

Note that your PV panels have a "maximum series fuse" rating written on their label. Where there are 3 or more strings to the array, this may result in the need for fusing of individual strings to protect against excessive reverse current. Reverse current in the event of a possible fault must not exceed this fuse rating.

If there are more than two strings in parallel then the maximum fault current that can arise (in reverse) in any one string is equal to the number of **other** strings connected, times the short circuit rating of each of those strings. Therefore if there are three (or more) parallel strings, the PV modules **could be** subjected to reverse currents of two (or more) times their nominal short circuit current. This reverse current rating (normally called maximum series fuse rating on the panel label) is different for different makes of panel and is typically in the range 15-20 amps for 250-300W panels.

When using 3 or more strings you should read the following extracts from the regulations (AS/NZS 5033) and our two worked examples, so you can be sure to comply.

3.3.4 String overcurrent protection

String overcurrent protection shall be required if—

$$\left((S_A - 1) \times I_{SC\ MOD}\right) > I_{MOD\ MAX\ OCPR}$$

NOTES:

1 Circuit breakers are not recommended for string overcurrent protection.

2 Where fuses are applied, these fuses need to be sufficiently selective (refer to Clause 4.3.8 for fuse requirements).

3 Overcurrent protection of strings with different current ratings is not covered in this Standard. These configurations are not recommended but when used for the overcurrent protection requirements should be analysed in detail for the specific application and PV module ratings.

1.4.22 $I_{MOD\ MAX\ OCPR}$

The PV module maximum overcurrent protection rating determined by IEC 61730-2.

NOTE: It is a mandatory requirement of IEC 61730-2 that this rating be specified in the documentation of PV modules (see Clause 5.7).

1.4.26 $I_{SC\ MOD}$

The short circuit current of a PV module or PV string at STC, as specified by the manufacturer in the product specification plate.

NOTE: As PV strings are a group of PV modules connected in series, the short circuit current of a string is equal to $I_{SC\ MOD}$.

3.3.5 Overcurrent protection sizing

3.3.5.1 *PV string overcurrent protection*

Where string overcurrent protection is required, either—

(a) each PV string may be protected with an overcurrent protection device (refer to Figures 2.3 and 2.4) where the nominal overcurrent protection rating of the string overcurrent protection device shall be I_n where:

$$I_n > 1.5 \times I_{SC\ MOD}$$

$$I_n < 2.4 \times I_{SC\ MOD}$$

$$I_n \leq I_{MOD\ MAX\ OCPR}$$

Renesola 260W module example

For 3 strings of Renesola 260W module, 3.3.4 states (3-1) x 8.95 = 17.9 < module OCPR of 20A.

Hence **no** overcurrent protection for 3 strings is required. Protection will be required when **4 or more** PV strings are connected to our SHP triplex.

3.3.5.1

- I_n > 1.5 x 8.95 = 13.43A
- I_n < 2.4 x 8.95 = 21.48
- I_n =< 20A

Hence a fuse =< 20 amp and > 13.43 A is required per string, but only when 4 or more strings are connected to an SHP.

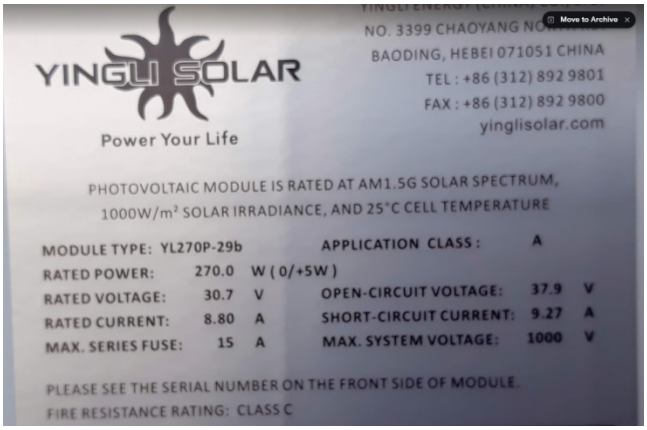
Yingli 270W module example

For 3 strings of Yingli 270W module, 3.3.4 states (3-1) x 9.27 = 18.5 > module OCPR of 15A.

Hence overcurrent protection will be required when **3 or more** PV strings are connected to our SHP triplex.

3.3.5.1

- I_n > 1.5 x 9.27 = 13.91A
- I_n < 2.4 x 9.27 = 22.25A
- I_n =< 15A



Hence a fuse =< 15 amp and > 13.91 A is required per string when 3 or more strings of **Yingli 270W** are connected to an SHP.

Summary (fuses required per string)

Panel example	1-string	2-string	3-string	4-string (not advised)
260W Renesola	N/A	N/A	N/A	14- 20 amp
270W Yingli	N/A	N/A	14-15 amp	14-15 amp

Note that 15 amp MC4 inline fuses are widely available and low cost

Hence is this example, for the correct application of AS/NZS 5033, some panel makes require string fuses while other makes **may not**. If you are careful in selecting the make of panel for your SHP-triplex application then you can avoid the need for string fuses.

Do both poles need protection?

AS/NZS 5033 states in section 3.3.6 that:

> In ELV arrays, overcurrent protective devices, where required for string and sub-array cables, shall be placed in **either** the positive or negative conductor (the number of current carrying conductors minus one). Where the extra-low voltage array is earthed, the protective devices shall be installed in all unearthed current carrying conductors.

Section 4.4.2.1 states:

> In PV arrays with a PV array maximum voltage **greater than ELV** and in systems which include a.c. modules and microinverters with LV outputs, all exposed metal PV module frames shall be earthed and the array mounting frames shall also be earthed. Earthing/bonding of exposed conductive parts of a PV array shall be performed in accordance with Figure 4.5 decision tree.

Hence there is no requirement to earth an ELV PV array, **only an LV one**.

3.2.4. Selecting suitable fuses where needed

Here is what the regulations tell us

4.3.8 Fuses

4.3.8.1 *General*

Fuses used in PV arrays shall—

(a) be rated for d.c. use;

(b) have a voltage rating equal to or greater than the PV array maximum voltage determined in Clause 4.2;

(c) be rated to interrupt fault currents from the PV array, and any other connected power sources such as batteries, generators and the grid, if present; and

(d) be of an overcurrent and short circuit current protective type suitable for PV complying with IEC 60269-6 (i.e. Type gPV).

The maximum voltage is found as follows (next page.)

4.2 PV ARRAY MAXIMUM VOLTAGE

The PV array maximum voltage is considered to be equal to $V_{OC\ ARRAY}$ corrected for the lowest expected operating temperature, as follows:

$$\text{PV array maximum voltage} = V_{OC\ ARRAY} + \gamma_v (T_{min} - T_{STC}) M$$

where

$V_{OC\ ARRAY}$ = open circuit voltage of the array at STC, in volts

γ_v = voltage temperature co-efficient, V/°C/module supplied by the manufacturer (negative value for crystalline silicon)

T_{min} = expected minimum daily cell temperature, in degrees Celsius

T_{STC} = cell temperature at standard test conditions, in degrees Celsius

M = the number of series-connected PV modules in a string

Correction of the voltage for the lowest expected operating temperature shall be carried out as follows:

(a) Using the formula above.

(b) Calculated according to manufacturer's instructions.

(c) Where manufacturer's instructions are not available for crystalline and multi-crystalline silicon PV modules, $V_{OC\ ARRAY}$ shall be multiplied by a correction factor according to Table 4.1, using the lowest expected operating temperature as a reference.

Where the lowest expected operating temperature is below −40°C, or where technologies other than crystalline or multi-crystalline silicon are in use, voltage correction shall only be made in accordance with manufacturer's instructions.

PV strings constructed using d.c. conditioning units shall have a PV array maximum voltage in accordance with Clause 2.1.5.

TABLE 4.1

VOLTAGE CORRECTION FACTORS FOR CRYSTALLINE AND MULTI-CRYSTALLINE SILICON PV MODULES

Lowest expected operating temperature °C	Correction factor
24 to 20	1.02
19 to 15	1.04
14 to 10	1.06
9 to 5	1.08
4 to 0	1.10
−1 to −5	1.12
−6 to −10	1.14
−11 to −15	1.16
−16 to −20	1.18
−21 to −25	1.20
−26 to −30	1.21
−31 to −35	1.23
−36 to −40	1.25

Renesola PV array maximum voltage as per 4.2 c)= (37.6 x 2) x 1.18 = 88.74V.
(Note that very few places in NZ get below -20C).

Hence all DC fuses rated for ELV solar PV applications (<120VDC) will be fine for use with our SHP-triplex pump.

A picture of a suitable MC4 fuse holder and 15 amp (IEC 60269-6) fuse opposite.

3.2.5. Lightning protection

In NZ no lightning protection is required as the risk is normally low. This may not be the case in Australia and other countries which may require lightning protection to be fitted and/or the PV frame to be earthed. In NZ lightening damage is normally covered by your insurance provider.

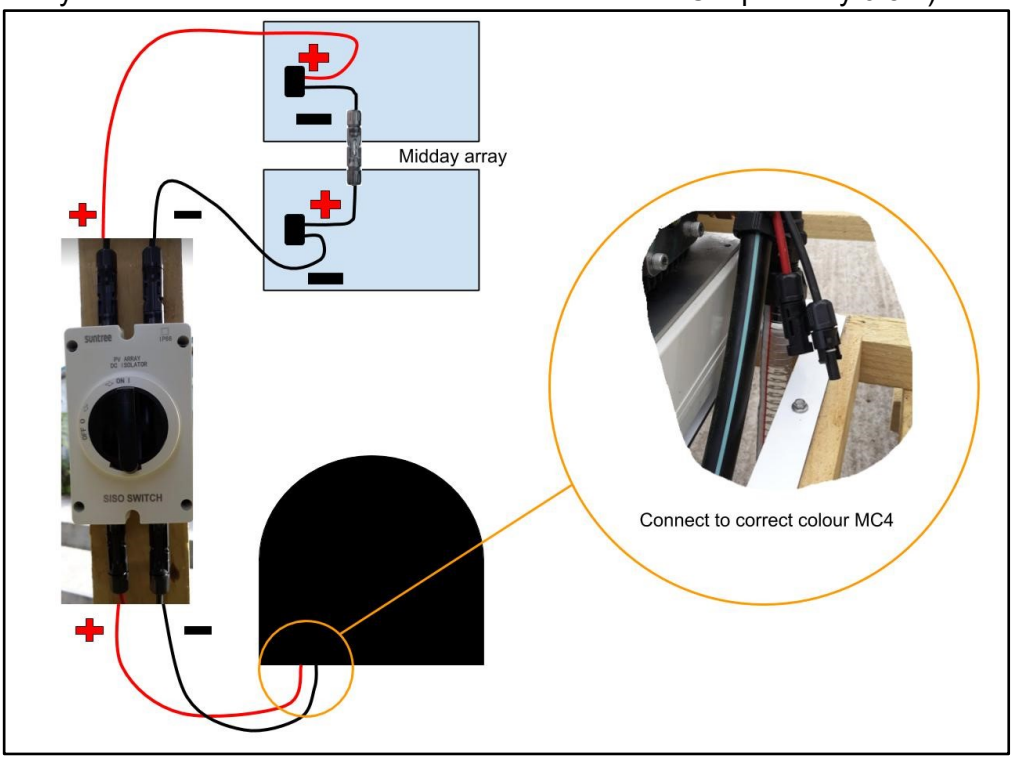
3.2.6. Earth Connection

In NZ the solar PV array does not need to earthed as the system is ELV and there is no lightning protection required. You can however earth conductive parts if you wish.

This may not be the case for Australia and other countries (where for example lightning is much more common).

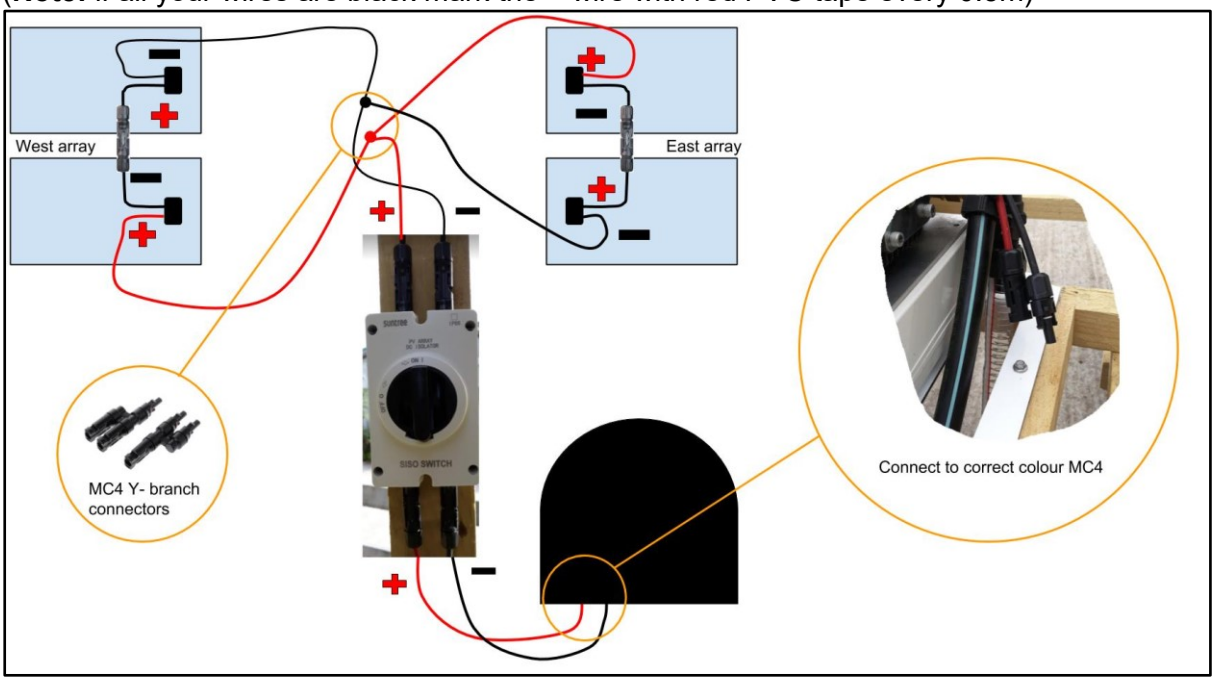
3.2.7. Wiring schematic for 540W PV array

(**Note:** if all your wires are black mark the + wire with red PVC tape every 0.5m)



3.2.8. Wiring schematic for 1080W PV array

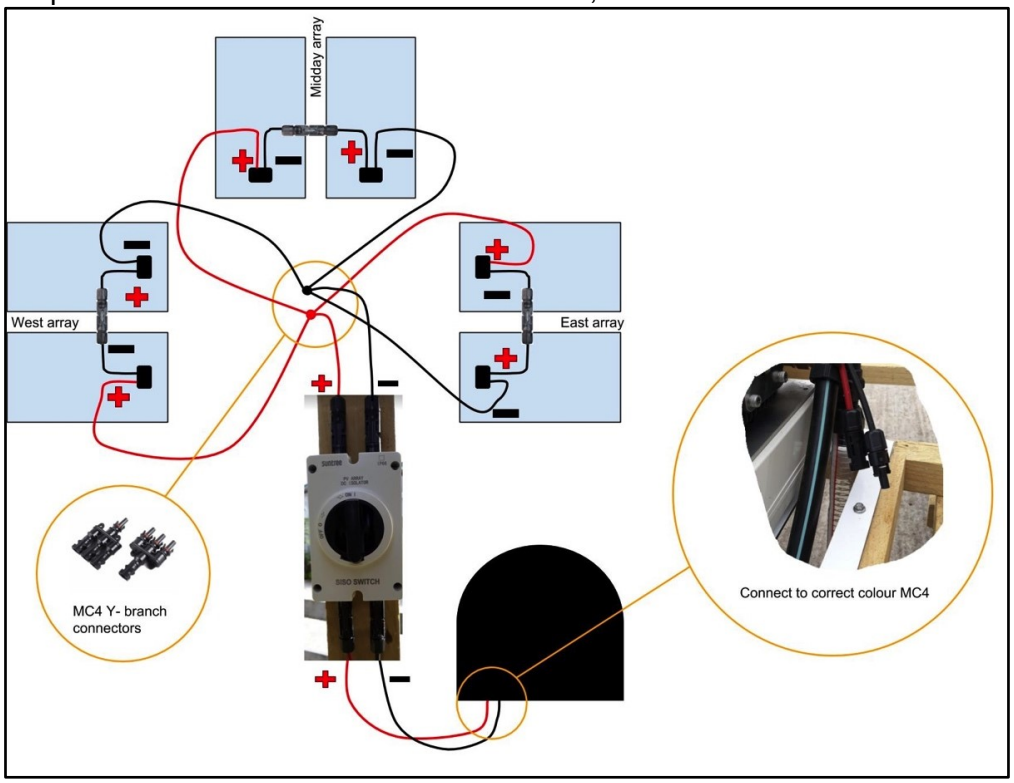
(**Note:** if all your wires are black mark the + wire with red PVC tape every 0.5m)



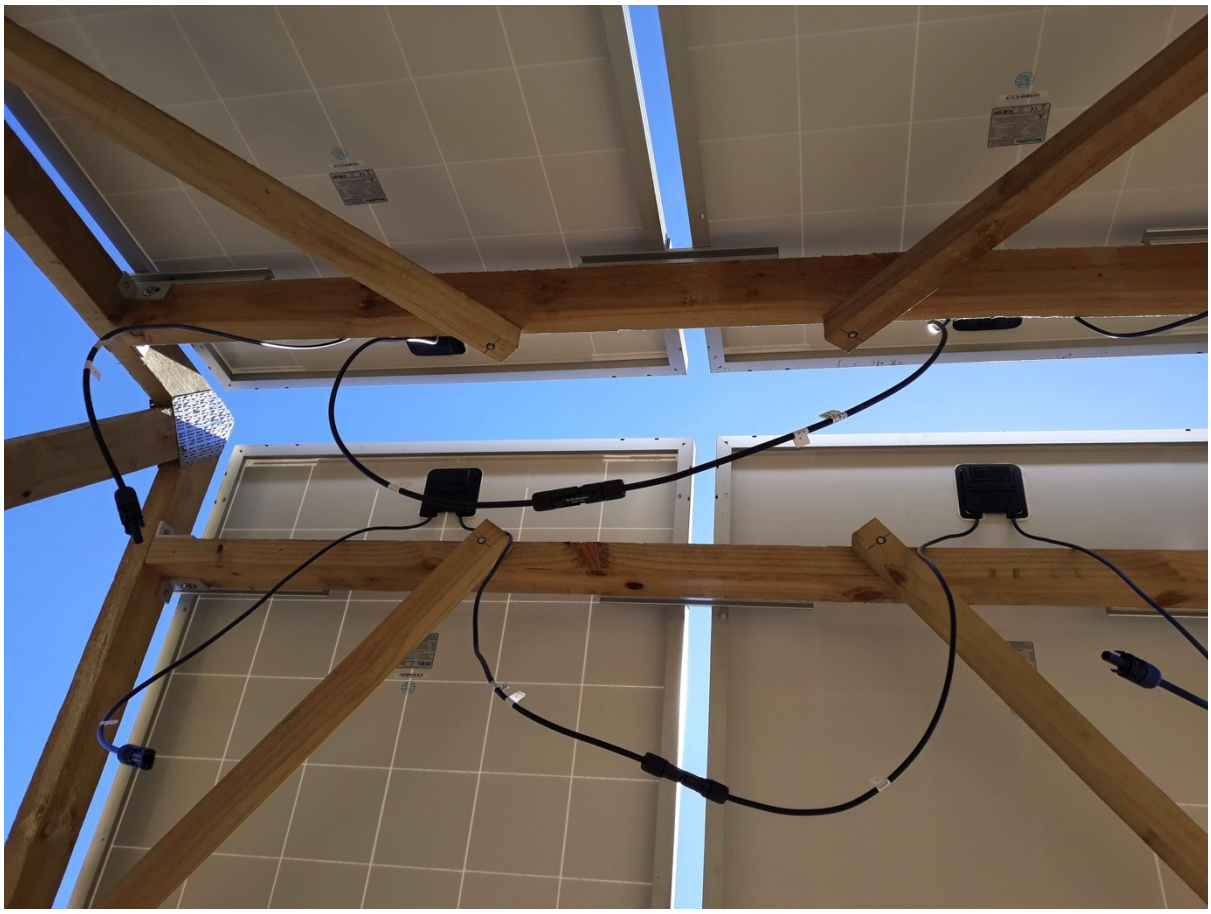
3.2.9. Wiring schematic for 1620W PV array

Notes:

- If all your wires are black mark the + wire with red PVC tape every 0.5m
- Check the maximum series fuse rating to determine whether string fuses are needed when connecting your panels in three strings.
- String fuses (if required) are not shown in the diagram below.
- If triple Y branch connectors are not available, 2 sets of doubles will do the same job.

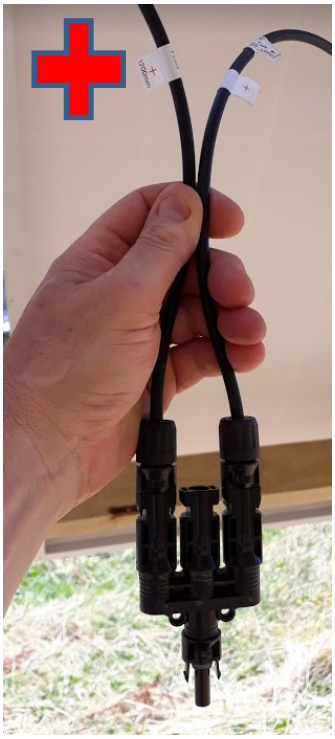


3.2.10. Solar array general wiring practice



Wiring is very simple.

Start by plugging together each panel pair in series as shown above. You are connecting a “+” to a “-“ of two panels that are mounted in the same orientation.



Connect the positive wires into the parallel connector. Note the connectors shown allows for 3 connections as may be needed for a largest 6 panel PV option (only double connectors are normally supplied with the SHP – you can use two sets of doubles for 3-string installations).

Connect the negative wires into the parallel connector.

If you have any unused connectors tape them up to keep them clean and water tight. They will then be OK if needed for a future PV upgrade.

Secure and tidy up your wiring in line with the advice in the section below.

Tidy and secure wiring on both sides as shown above

If you are mounting one of the following:

- 4 x PV panels all positioned for midday sun
- 4 x PV panels not on an East/West truss frame (as per this example)
- 6 x PV panels all positioned for midday sun
- 6 x PV panels in an East/Midday/West position or on a large truss

then the leads from each PV panel pair may not all be long enough to reach the parallel connectors. In such cases you will need to add an MC4 extension wire. These are easy to make onsite to the length required or they can be purchased pre-made. Remember if you are making extension leads have a male plug on one end and a female on the other end. Get this wrong and you will change the polarity of the wiring which will damage the SHP.

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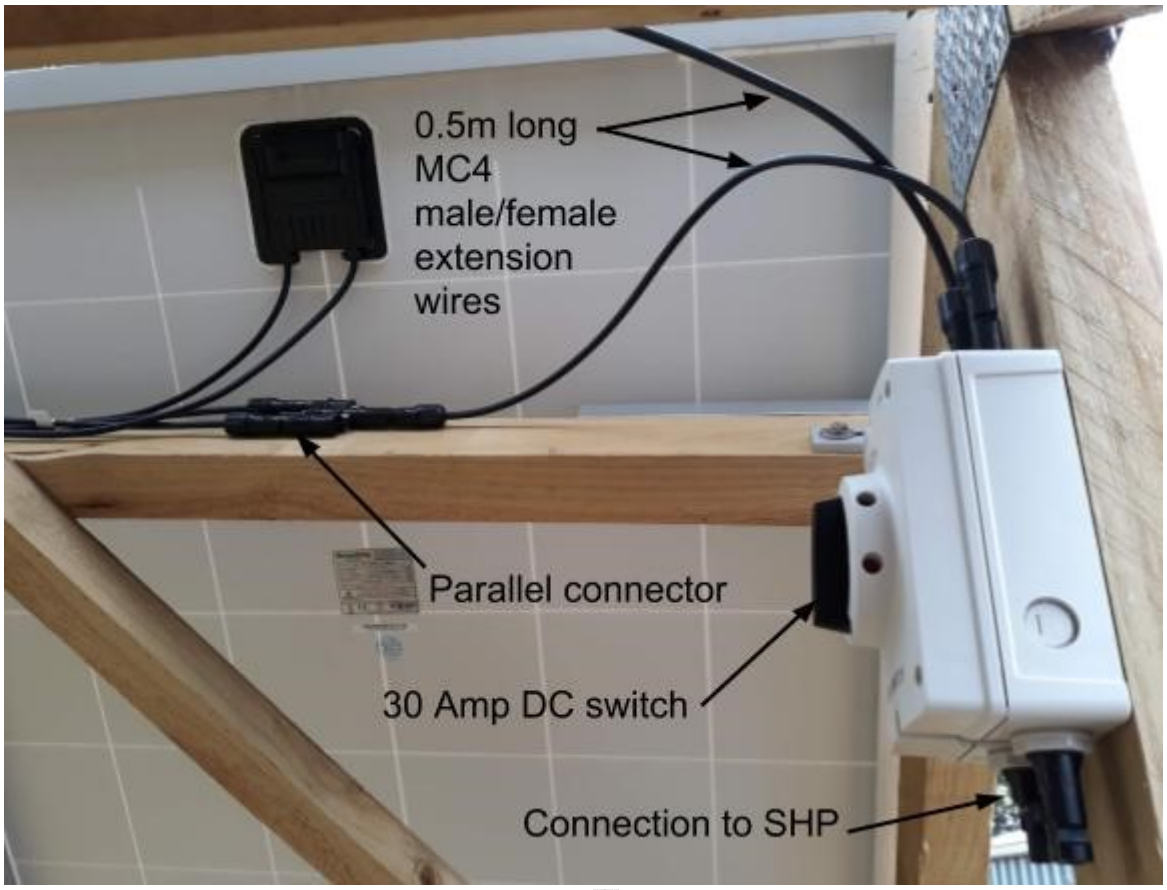
3.2.11. SHP-Triplex wiring to main DC disconnect switch



Each SHP-Triplex is supplied with a waterproof MC4 DC switch for easy and fast connection as shown above.

3.2.12. SHP-Triplex wiring DC switch to SHP

The wiring from the DC switch may need to be in secured conduit to protect it from animal damage. In general large animals should be kept out but smaller animals may get in and chew on wiring.

Rats and other small gnawing rodents can be very difficult to keep out. Putting a metal skin around the 4 posts of a trussed mounted array can prevent rodents from getting up onto the unprotected PV wiring. To keep out possums the entire 1.2m long post will need to be skinned, for smaller rodents 600mm is fine. Normally stainless steel sheet material is used.

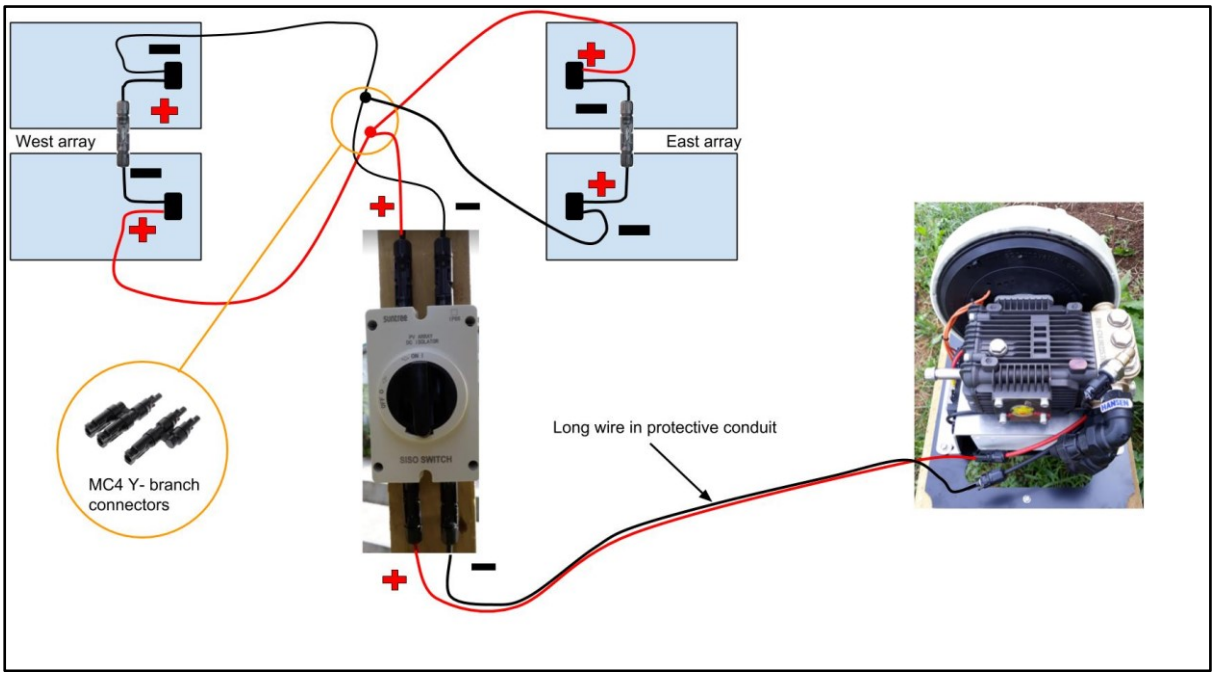
3.2.13. Check polarity

With the switch on in good sun, red lead in + MC4 fitting as shown check:

- Voltage is typically in range 65-75V, 68 in this example.
- Confirm polarity, -68 would be the wrong polarity.

Wrong polarity is due to a wiring error from the panels to the switch or lead colours in your multi meter being wrong.

3.2.14. Final wiring to SHP (1080W example)



3.2.15. Regulations about cable ties, and UV protection of PV wiring

In NZ & AUS the cited AUS/NZ 5033 standard specifically outlaws the use of plastic cable ties to secure PV wiring. The reason for this is that thin plastic ties outside do not last long in our harsh UV sunlight (this is even the case in the shade), the cable ties break and the wires are then buffeted by the wind and get damaged. This can be a serious issue on higher voltage LV systems. There is no ELV exception to this requirement on systems larger than 240W. Use plastic ties first as they are easy to use, then when all tidy place a stainless one alongside each plastic one. You will have noticed that our East/West truss mounting does not require any cable ties as we have used PVC saddles. Some installation variations may require them.

PV wires are double insulated with UV rated plastic and when located in the shade under the panels require no extra UV protection to achieve an acceptable life. Where the cables are exposed to direct sunlight and for animal nuisance protection, then sleeving in LDPE pipe or PVC conduit is required.

Rodents - A key ingredient to PVC is salt (which rodents like to eat), which makes PVC low cost and fire resistant. Rodents also need to chew and will often chew on PVC wires and PVC protective conduit for these reasons. Keep an eye out for this damage over time, as it can cause shorts, water ingress and ultimately the loss of power to the SHP.

3.2.16. How to feed your electrical wire inside a long LDPE pipe.

You will need to protect the wires from the bottom of the switch box to the SHP. Here is a simple technique for feeding wires through a LDPE pipe that works well in remote locations. You will only need a farm bike and a length of string at least as long as the pipe.

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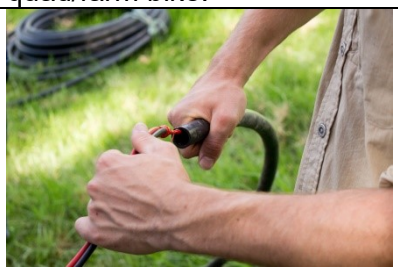
Drill a small hole for a string line near the end of the pipe. Make a pipe pig of a rag and fasten this to the string inside your pipe.	 Tape the LPDE pipe so it fits into the exhaust pipe of your quad/farm bike.	Rev the engine and help by feeding the string into the hole Pipe runs up to 50m long are easy to do this way If longer, then do 50m at a time, and use a joiner
 Once through, connect wire to the string securely and tape	 Pull wire through pipe	 Connect to switch box under the PV array

The bike exhaust method works for PE pipes up to about 75m long. For longer PE protective pipe runs consider these options:

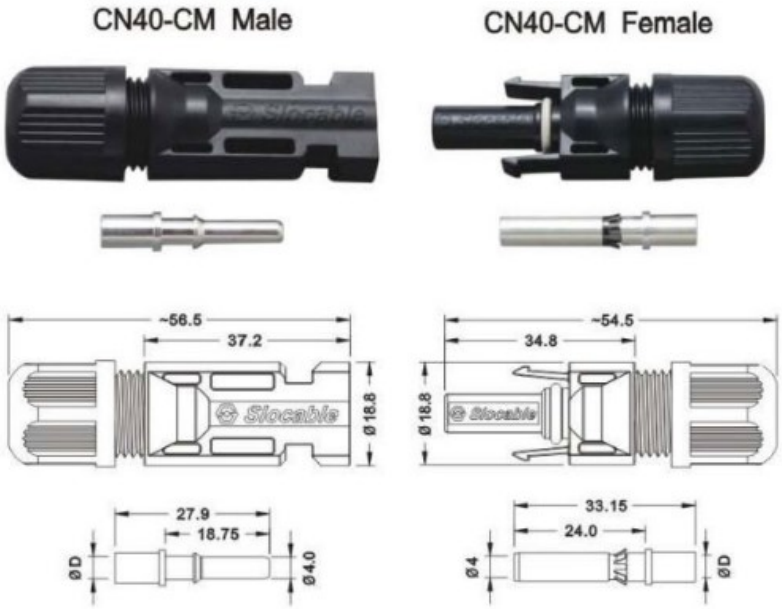
- Small generator set and air compressor.
- Small generator set and vacuum cleaner.
- Using the water pressure from the SHP-triplex.

We have used all these methods in the past and all have worked well.

3.2.17. How to wire and fit the MC4 connectors

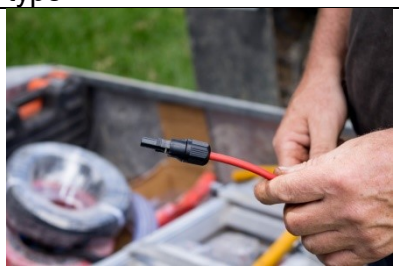
The MC4s connectors are either male or female. Each plug type carries a + or – sign. The convention is to have the + on + ive generation wires and – on –ive generation wires. If you check the voltage polarity of the pre-wired MC4 connectors on the solar panels you can confirm this. (All wires on PV panels are black, but they carry a + or – marker tag on the wires.)

The confusing part (and a common error to make) is when fitting MC4s to load wires (i.e. the wires <u>to the SHP</u> which is the electrical load). In this case a –ive wire will have + MC4 fitted and a +ive wire will have a –ive MC4 fitted.



You can only get the polarity wrong if you have made up extension cables that are male/male or female/female instead of male/female. If you do this you will kill the BLDC driver in the SHP, so you must take care, and read what follows very carefully.

3.2.18. To fit MC4 connectors with correct tools (barrel crimping tool):

Strip off 8mm of PVC sheath	Crimp on fitting of correct type	Slide on nut and seal
Do not mix up MC4 parts! Keep them in separate bags to avoid errors. The body of the MC4 fitting pushes over the crimped metal inner until you hear it click.	 Tighten the nut	If you make an error the MC4 will have to be cut off and thrown away. if you are still unsure seek help from an electrician.

The make of MC4 we use (Slocable brand) requires no special tools other than a 4mm barrel crimping tool. If you do not have access to a crimping tool then fencing pliers and a drill bit suffice.

We also can sell you the correct crimping tool if required.

3.2.19. To fit MC4s with available farm tools:

Use a knife to strip PVC sheath back as shown (longer than normal)	Slide on metal fitting and crimp hard as shown	Crimp again with the blunt end of a 3mm or 3.5mm drill bit inserted as shown
Push the metal fitting into the plastic connector untill it clicks. You may need to use a small flat screwdriver to help	Push in surplus wire as shown so that the seal and nut can fasten on the PVC	Tighten the nut and pull hard to check it is firm

3.3. Operating your SHP from auxiliary (not solar) power sources

3.3.1. Systems with a 230/115 VAC supply

It is possible to run the SHP off a 230 or 115Vac supply with a suitable power supply. For example a small 2kVA portable gen-set could be used to run the SHP at night so the tank can be refilled at times of very high water demands. You may need a COC for the VAC part of your system installation (as 230/115 VAC is "LV"). Seek advice from your electrician.

You will need an 80V 1kW power supply to do this. These you can buy online (for example) here.

Example of a suitable power supply unit on the market:

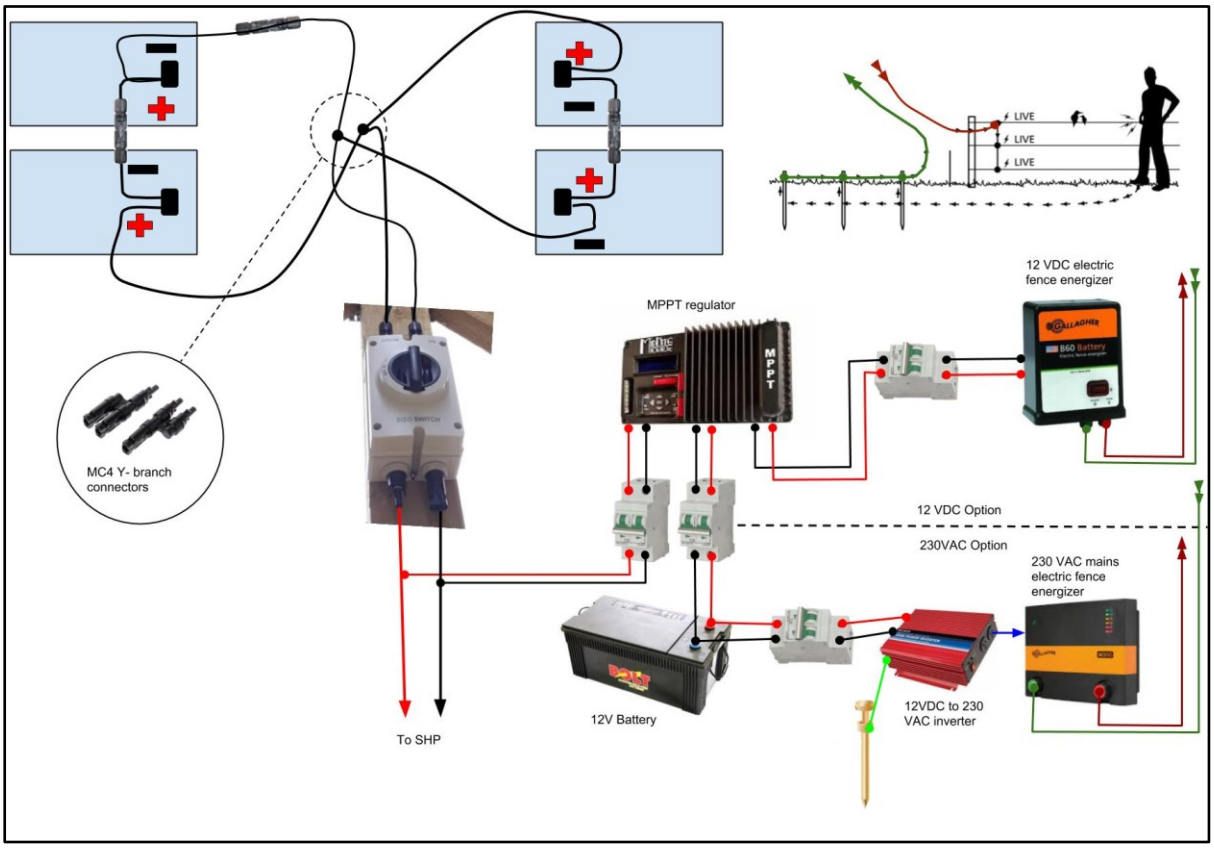
3.3.2. Using the SHP solar array for other purposes

Some farmers needing water over the back of their farm may also need a decent electric fence, and power for communications and tools. The solar array powering the SHP can often meet these needs as well. This is easy to arrange, so consider doing it at the same time:

- Skin the East/West truss mounted PV frame in plywood and/or corrugated steel and make a watertight building.
- Install a large 12V N200 truck battery in this building.
- Note that your PV array will require over-current protection (circuit breaker) when connected to a battery-based system due to the risk of high reverse fault currents.
- Install a MPPT charge controller to charge the 12V battery. Program your controller with the correct bulk, float & EQ settings for your battery. Maximum input voltage limit of this controller should be at least 100VDC.
- Fit a 12V electric fence energised for smaller farms
- Fit a small AC sinewave inverter and mains powered electric energiser for larger farms. Note: AC wiring work may need a COC and have to be done by an electrician, so seek advice first.

The power needed to run an electric fence is low and will not significantly reduce the amount of water pumped. On sunrise the MPPT controller will bulk charge the battery, and this may delay starting of the SHP a little.

Farmers who need to pump more water and also need power for tools etc., should consider expanding the solar to 6 x 270W PV panels. Having reliable power at a shed on your remote farm can aid farmer/worker safety.



Basic wiring schematic for 12VDC or 230VAC electric fence energizer

4. Intake

In NZ most water resources are from springs or small streams on falling land. Often it is just a collection of springs in a small gully at the base of higher hills that can provide 0.1-0.5 l/s flow rates. Some earthwork may be needed to provide:

- Consolidation of a few small springs.
- A storage buffer (night time water accumulator).
- Sufficient water depth for a foot valve intake and floating pontoon.

4.1. Suction or gravity feed (pump priming issues)?

Gravity feed the SHP if you can. This will avoid issues with having to manually prime the pump as a result of air getting into the suction pipe.

An SHP can develop good suction head against an empty delivery pipe. It will usually prime itself without problems on first use for suction heads up to 3 metres (up to 4.0 m with wet valves), but it will not pump the next morning if air enters the suction pipe. It can suck water up 3 metres first time, when the delivery pipe is empty. If the delivery pipe is full and there is air in the suction pipe then the SHP will need to be manually primed. A foot valve is required to maintain the prime and it must be kept in perfect working order, hence good access to this valve is important. It is essential to buy a spare foot valve so you have one when required.

Prime can be lost (air enters the pipe) if:

- Suction fittings are not airtight or have worked loose.
- Suction hose has rubbed on a rock and developed a pin hole.
- Foot valve is partially open due to grit stuck on the seat.
- Foot valve is badly worn and no longer water tight, so leaks down at night.

To avoid loss-of-suction issues:

- Keep your suction pipe as short as possible.
- Keep your suction lift as low as possible.
- Ensure the foot valve seat is clean and in good condition protected by a suitable filter sock.
- Ensure the foot valve is off the bottom of the stream/pond where grit can damage it.

Unlike long stroke piston pumps used on many farms, the SHP cannot expel air against a pressurised supply line. So if prime is lost with a full delivery pipe, then it will need manual assistance to prime. See the "Operation" section for details of how to prime the SHP.

Long stroke piston pumps (typically 75mm stroke & common on many farms as shown opposite), have a higher compression ratio so they are able to compress air in the body of the pump to a pressure greater than the static water pressure in the supply line (up to about 50m heads only). Hence they are able to prime themselves while working against a head of water pressure, without the need for a foot valve.

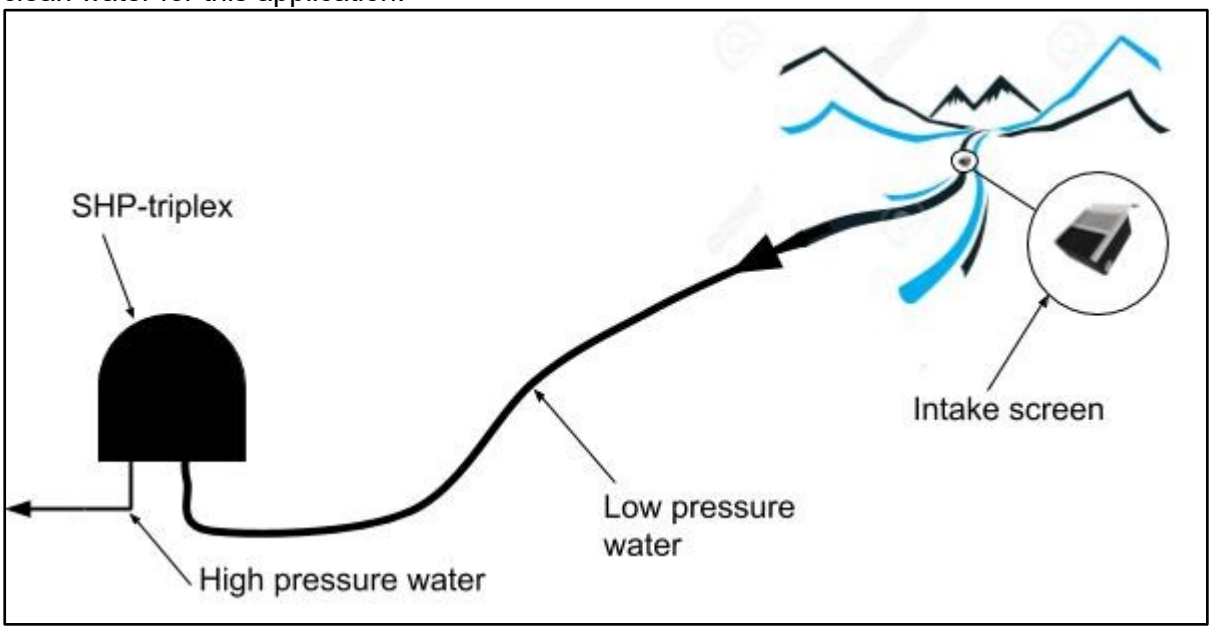
An SHP-Triplex has 3 small stroke plungers (14mm not 75mm stroke) and these plungers do not run is a close fitting bore. This means its compression ratio when compressing air is lower than that of a piston pump, the peak air pressure in front of the plunger may be less than the water pressure already in the delivery line.

4.2. Site installation options

The following installation examples are illustrated in preference order.

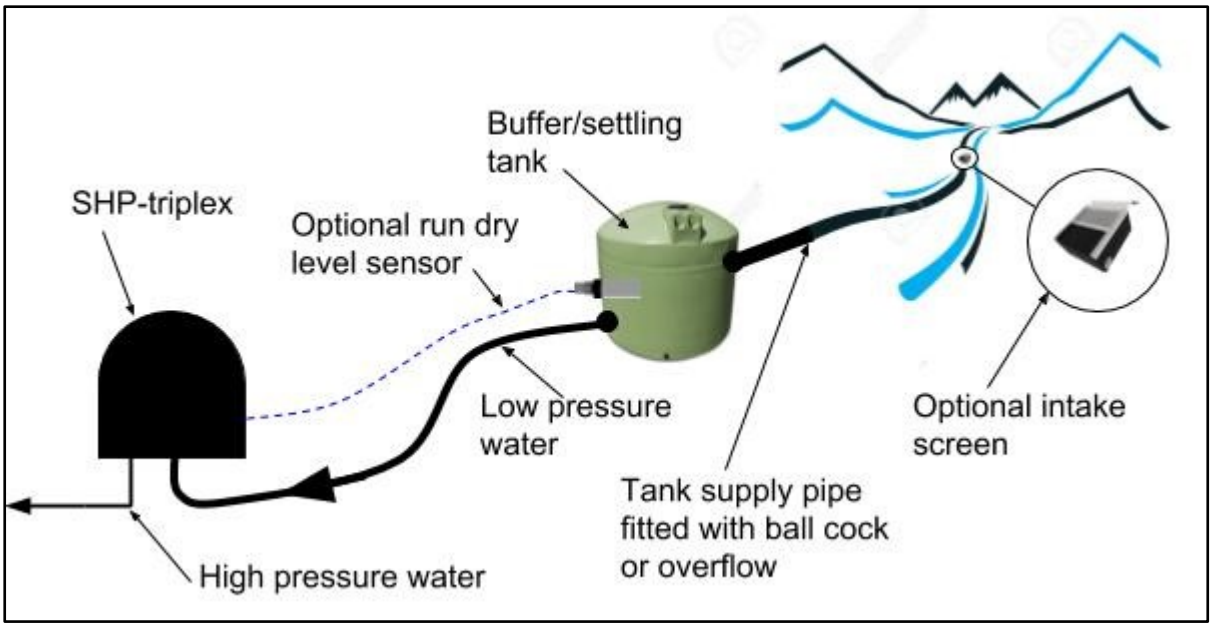
4.2.1. Gravity feed (very little fall – small creek or stream)

Choose a site for the pump that is slightly below the point where water is extracted from a small creek or stream. The pump will prime itself. Our Coanda intake is ideal for collecting clean water for this application.



A 1-2mm intake screen to filter flow is required

4.2.2. Gravity feed with silt settling tank (where more fall allows)



A 1-2mm intake screen to filter flow is advised

The above examples will self-prime and are very unlikely to air lock. Gravity feed is the best solution if you have such a suitable stream resource.

Where flows are always greater than 0.3l/s (per SHP installed) the intakes commonly used for small hydro turbines can be employed. Your 25 ID pipe (larger pipe may be needed for longs run or multiple SHP's) is fed water via an angled intake screen. Surplus water keeps the screen clean.

To review our advice for small hydro turbines click here. We suggest using the same technique, but smaller than most hydro examples.

Remember, intakes have to be strong to survive floods and your SHP must be mounted above the maximum flood height unless a pontoon is used.

If your stream has more than 5l/s flow, and has enough fall then our PHP (our water driven pump) may be an even better option than our solar driven SHP.

The intake of a gravity feed SHP should be positioned at the base of a small set of rapids (to allow room for a sloping intake screen as shown opposite). Channel the water flow over the top of the screen, so it falls through the holes into the chamber below that feeds the "suction" line of the SHP. Leaves and twigs are washed away with surplus water preventing the intake from blocking.

Intakes often need to be made to suit the particular site. An angled guide and screen is the recommended way to make a good strong maintenance-free intake screen. You must ensure you securely attach the intake header tank and screen to the riverbed by driving galvanized stakes into the ground, or by attaching to large boulders with brackets, bolts and cement.

Intake screens can be purchased. Opposite is a leaf slide made for domestic downpipes. These are a perfect size for SHP intakes and are available with fine screens. They are mass produced and low cost. Perfect for small gravity intakes, where you have a suitable fall from your water resource to the SHP.

However, they are also easy enough to make to suit your site. You can use a stainless steel mesh and a plywood box or plastic tank. 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 or perforated plate with a hole size typically 0.5-1mm should then be placed over the stronger frame. This smooth screen will allow debris to slide off easily and prevent small aquatic life forms and insects from entering the suction line. Coanda type screens are even better, and we can supply these.

If the flow rate in your resource is below the SHP peak pumping rate then air may be drawn into the suction pipe. The pump may be damaged when this occurs. On sites where the flow varies or the intake filter gets clogged, you may benefit from using a buffer tank and a float switch as described later, to switch the pump off (using its "ignition switch" wiring) when the water level falls. Do not install a switch on the PV supply wires themselves unless it is suitably rated for the 80VDC.

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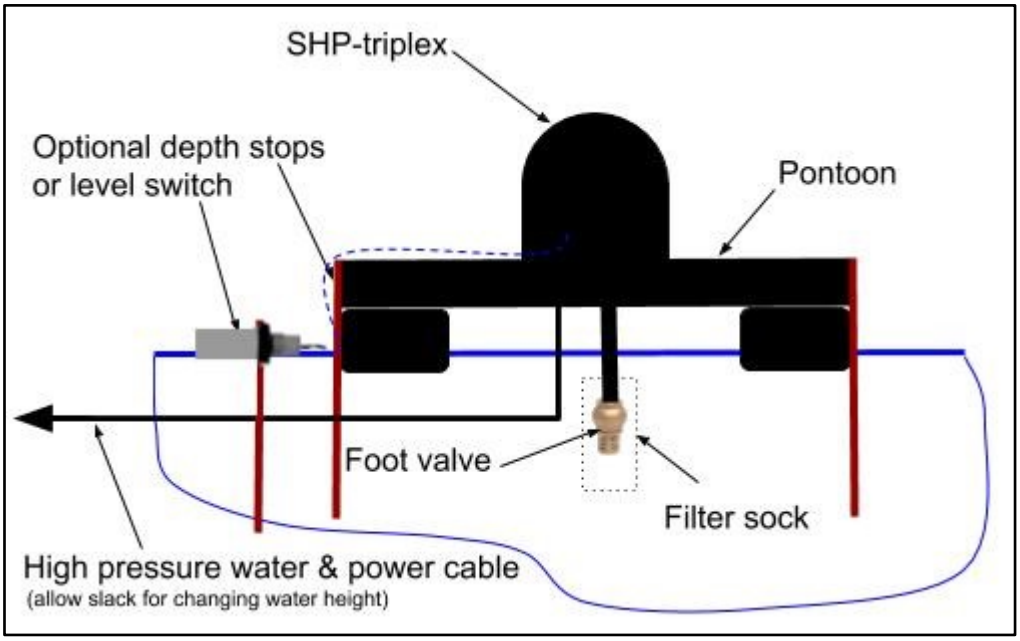
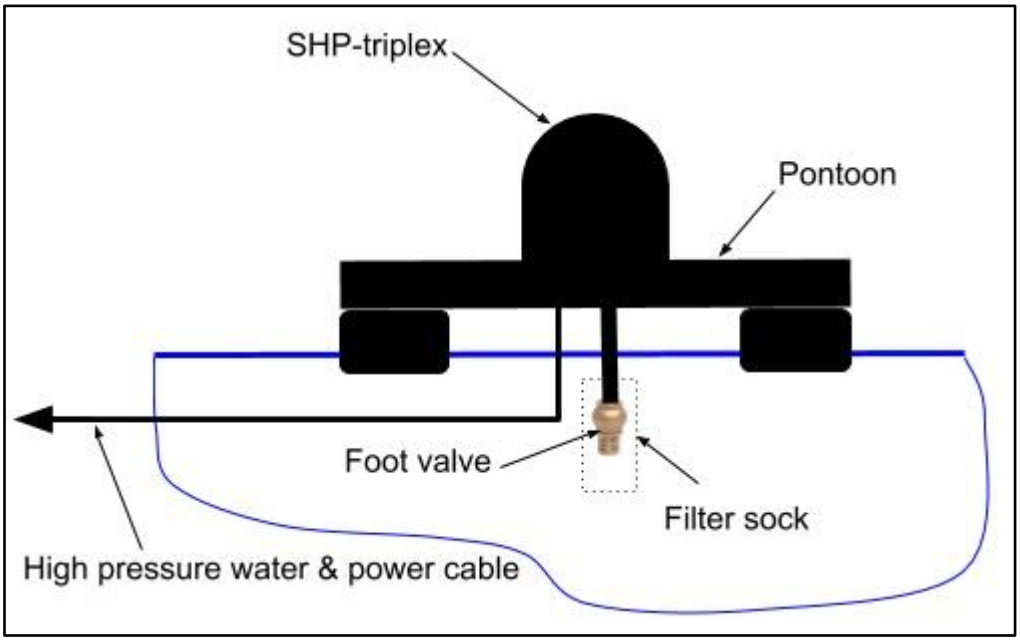
4.2.3. Small pontoon (pond, dam, stream or small lake with changing surface level)



Note the pump should not be allowed to operate unless the foot valve is fully submerged.

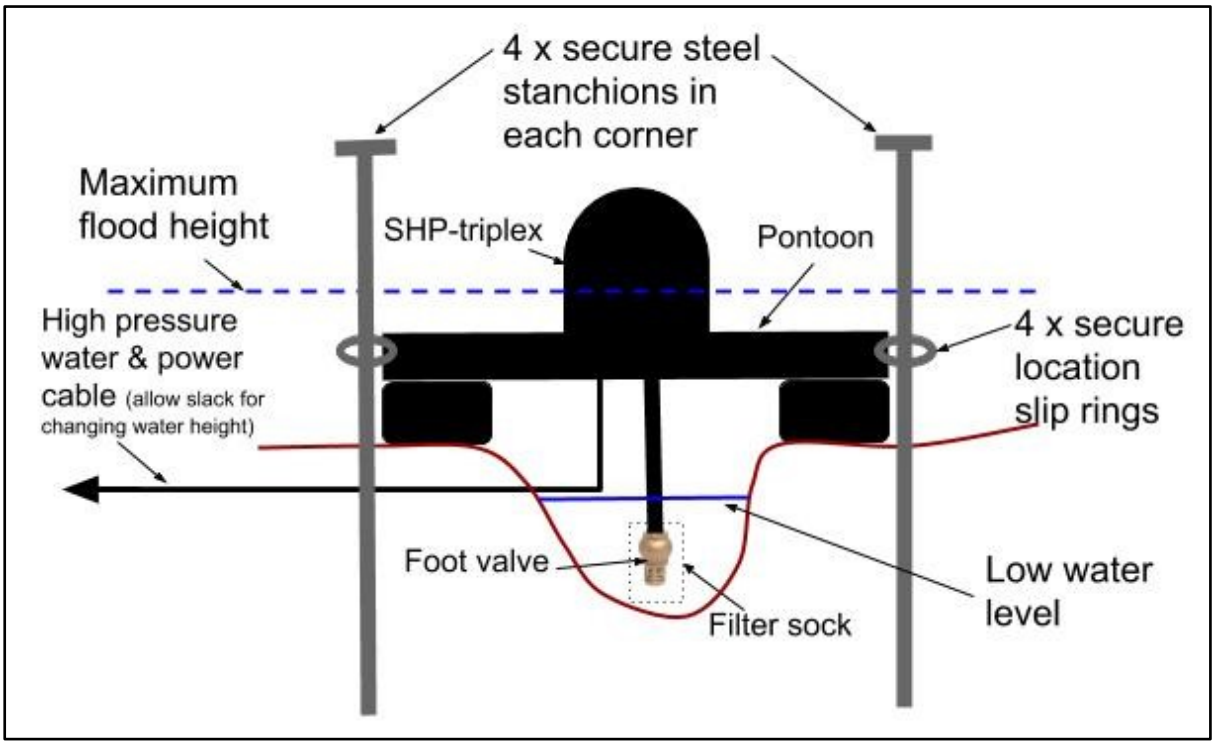
4.2.4. Small pontoon (large water surface with little change in surface level)



Please note that all pontoons used on streams or rivers need to be adequately secured against flood flows and flood debris. For lakes and dams (that are not exposed to such risks) ropes from the pontoon and anchored to the bank are sufficient for the pontoon to maintain location against strong winds and water currents.

Pontoons mounted on fast flowing water surfaces need careful consideration as the risk of complete equipment loss in floods events is high. Refer to the next section for guidance on such applications; also talk to your insurance company if you intend to implement such an installation. EcoInnovation is not liable if your pump is destroyed by flood waters.

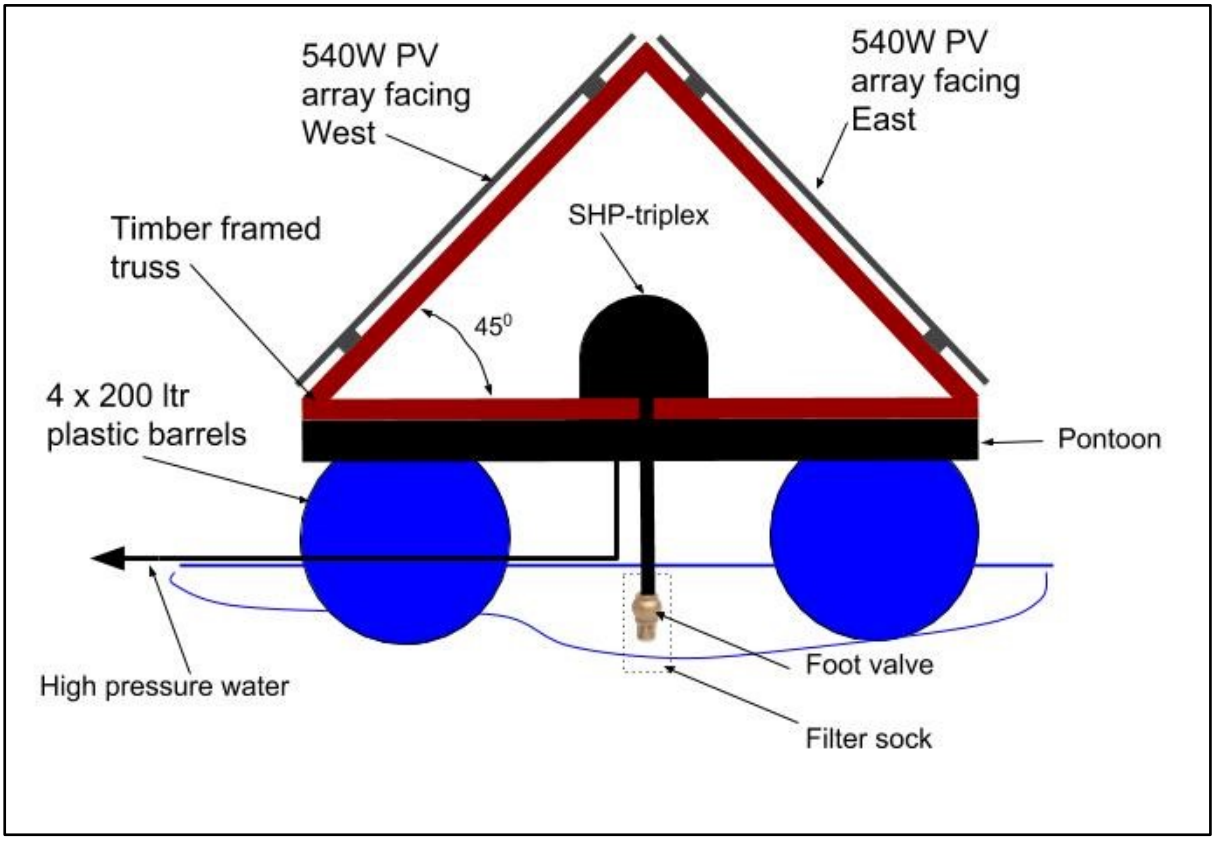
4.2.5. Small pontoon on rivers subject to moderate flooding



Such installations are ideal for small streams and rivers where occasional flood flows breach the river banks. Do not install this solution on the following streams and rivers:

- in deep ravines (use the bore pump option that follows)
- subject to large boulders and trees descending in the flood flow
- subject to high flood velocities

4.2.6. Larger pontoon with solar PV and SHP (large water surface with changing surface level)



Larger lakes and dams can accommodate the solar PV array on the same pontoon as the SHP-Triplex. The advantages are:

- Large lakes and dams may be relatively shade-free and exposed to all day sun.
- Different orientations of the PV array are very easy to make.
- Pontoons are low cost to make from surplus 200 litre plastic drums and treated timber (both common on farms).
- The PV array does not need any extra fencing to prevent animal damage.
- The PV array can be lower, as long grass shading the panels in not an issue.
- Shade from the pontoon may help to prevent water weeds from growing into the intake foot valve.
- Reflection of sunlight off the water surface can assist solar PV power generation.
- Security of the equipment from theft is improved (although theft is less common these days as PV prices have fallen).
- The power cable is short, reducing cost and improving efficiency.
- The power cable does not enter the water (reduced risk of damage).
- PV panel shade on the SHP casing helps to keep it all cooler.
- The risk of pump damage due to freezing from heavy frosts is lower, as the large water body keeps the night time air temperature higher than on land.
- The pontoon can be made off-site in your workshop and taken to site on a trailer when completed.
- Water is always close by to wash the PV panels as needed. PV panel washing can be automated as you have high pressure water available. It is important to keep your PV panels clean at times of peak water demand.

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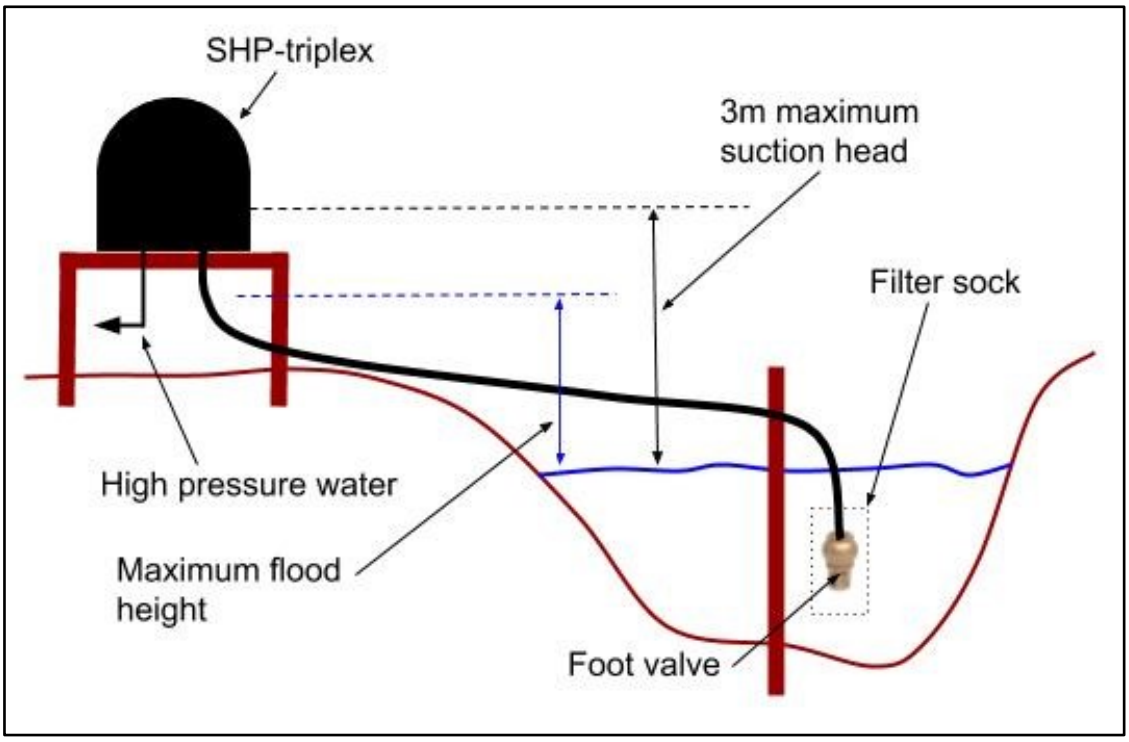
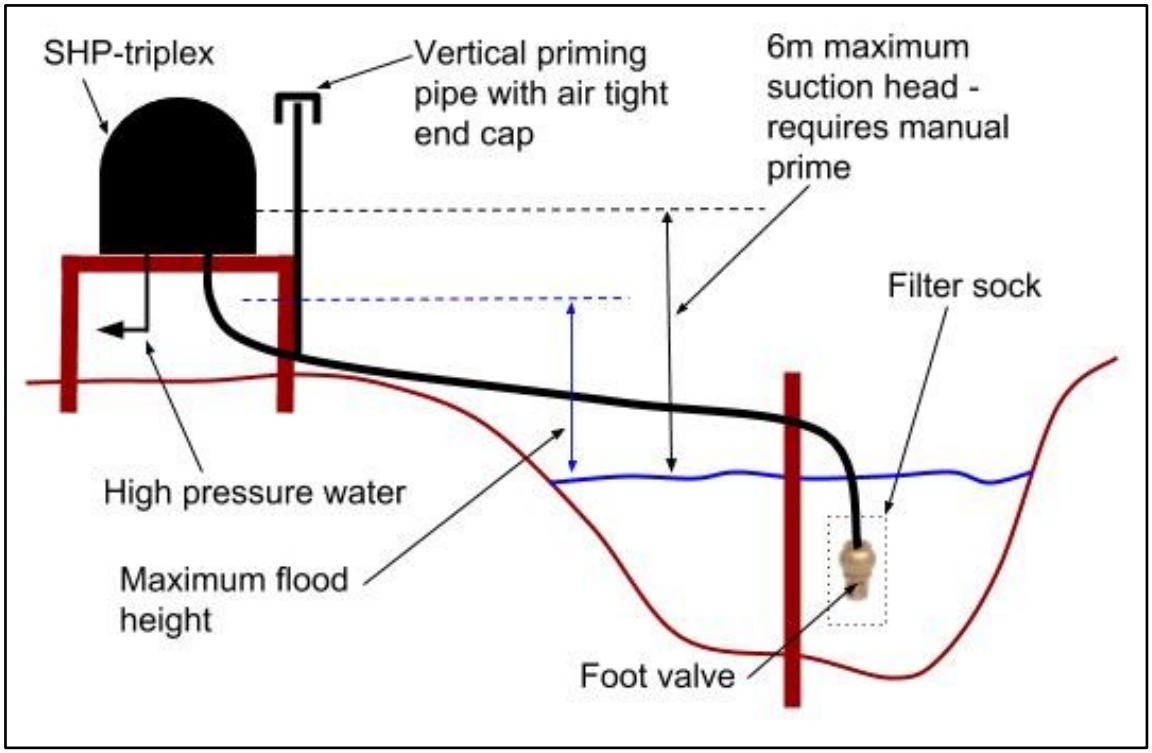
4.2.7. Suction lift up to 3m will self-prime

The pump can be ground-mounted at a height less than 3m above the water surface and it will prime itself. This is not advisable where flood levels can reach the pumps and submerge it in water.

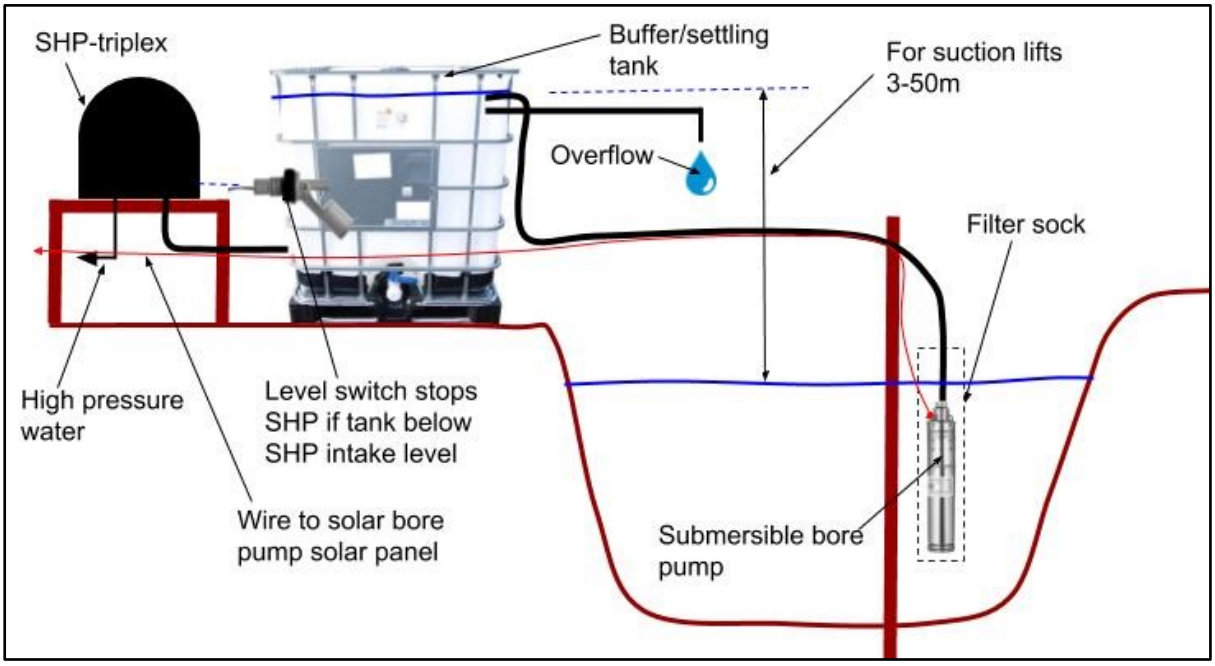


4.2.8. Suction lines with 3-6m lift will need to have a manually assisted prime while turning on the SHP



Pontoon applications (if possible) are preferable to suction lifts over 3m.
Submersible self-priming suction pumps (that follow) are also an option for lifts > 3m.

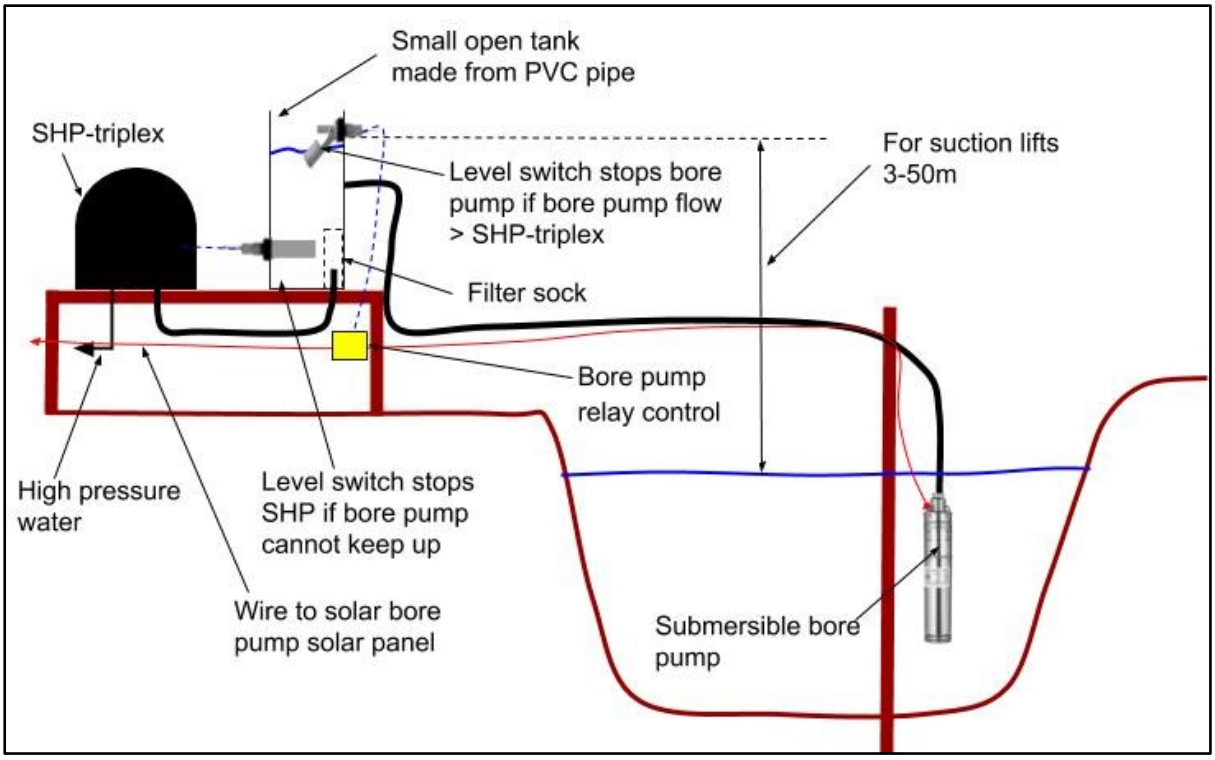
4.2.9. Submersible pump & settling tank for dirty water supplies from 3-50m below the SHP



Note the buffer/settling tank and float switch will accommodate flow variations between the SHP-Triplex and the small low cost bore pump while always ensuring a positive head to the SHP-Triplex.

Note: that bore pumps with external controllers can have an external float switch added to stop the bore pump when the buffer tank is full. Bore pumps with internal controllers (as shown above) can also be fitted with float switches; refer to next example.

4.2.10. Submersible pump with clean water from 3-50m below the SHP



4.2.11. Choosing a submersible bore pump

The world is awash with low cost submersible pumps that run off a single solar PV panel, typically 240-300W in size. These are ideal as a pre-lift pump to our high lift SHP-Triplex where your suction lift is too high and you cannot use an SHP-Triplex on a pontoon.

These submersible pumps are mass produced with prices starting from $150US. They are ideal for eliminating high suction lifts where a pontoon solution cannot be accommodated. Some makers of bore pumps offer them for lifts over 100m head, but be warned they are typically only 20% efficient at these high heads, so you will need a large solar PV array to use one on such a high head. They are much more suitable for 3-30m lifts where little power is needed, and 1 solar panel can do the job.

Buying a small submersible pump online can be overwhelming as there as so many options. So here are a few tips. Buy one that:

- Can run on a single 240-270W panel.
- Can lift to about twice the head you need. The head stated in the sales description is the maximum head were flow drops to zero, and often the stated flow is the maximum flow at no head. Often this is not made clear.
- Includes an MPPT controller inside the pump body to keep it all simple.

Such pumps are about 20-25% efficient. The seller may claim otherwise or not state this information at all.

For example, say you need to lift to 20m (to get water from a deep ravine), and need to pump up to 20 l/min in peak sun to keep up with the SHP-Triplex. (You need less than 20 l/min for a SHP-Triplex so this is plenty, but your single panel will be pointing at midday sun.) Then consider this option.

At 20m head, 260W input power, 25% efficiency we could expect:

- Power in 260W (rating of pump)
- Pumping power out = head (m) x flow (l/s) x 9.81 / efficiency = 20 x 20/60 x 9.81/0.25 = 262W

So it looks suitable for the job.
But in most cases you should be able to avoid using a bore pump like this.

4.2.12. Key parts to a good suction intake design:

- 25mm ID **short** suction hose (5m lengths are supplied in NZ with SHP) with as little lift a possible, and never more than 6 metres (ideally <3m).
- 1 x 25mm foot valve and pipe clamp (supplied in NZ with SHP).
- 1 x foot valve filter material and supporting wire frame basket. Note large drawstring laundry wash bags make great large particle filter socks as they are designed to allow free flow of water. These bags can normally be purchased at your local shops. They are also easy to make from offcuts of fine net curtain material.
- Steel/timber pegs as required to secure intake (not supplied).

The stainless wire basket ensures that the filter bag does not collapse around the foot valve which would reduce the effective filtering area. The large surface area of the filter bag means that it will not need cleaning often. It is does need cleaning/replacing too often it is too small or too fine a weave, make a larger one and fit a courser weave sock.

The filter bag should be replaced as required. An intake that needs cleaning every 2-3 months or longer is a realistic goal to work towards in the design of your intake.

If after removing the filter sock, the foot valve strainer is completely blocked with debris after only a short duration, then fit a larger wire basket and finer fabric screen until an acceptable cleaning duration is achieved.

For reasonably clean water resources the filter screen supplied will work fine and prevent small (< 1mm) aquatic life forms and particles from entering the suction line. With the filter bag removed the foot valve strainer would quickly block with leafs and grasses. Removing the foot valve strainer risks pump damage and is not advised.

The picture opposite show a filter material wrapped several times around the wire mesh basket over the foot valve. It has been secured in place with cable ties. Such a solution will last about 3 months in a clean water resource after which the material should be replaced and the foot valve cleaned. Dirty water resources are likely to need a larger intake to reduce cleaning intervals.

4.2.13. Filter sock advice

It is surprising how quickly a filter sock can become completely blocked. Once this occurs the suction increases which can lead to cavitation, loss of water prime, overheating and pump damage.

We advise a filter sock with a 1mm opening wrapped 2-3 times around the intake basket. Small particles can pass through. Particles larger than 1mm will get stopped mainly by the material. The best material we have found for making filter sock is net curtain material.

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4.2.14. Filter sock too small with tight weave

A small cotton filter sock (as shown opposite) became completely block after only 2 days of water pumping.

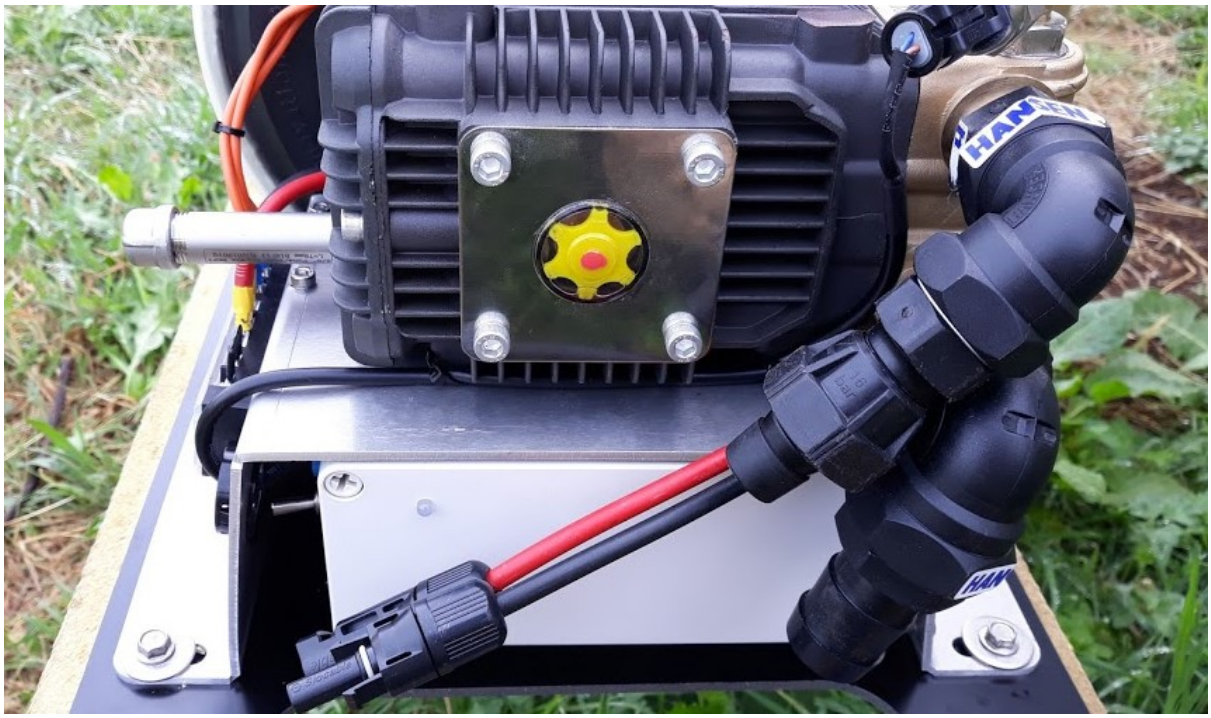
The stainless wire frame has prevented the sock from collapsing. Testing the sock showed it would hold water when filled. Such cotton socks are not suitable as the fine weave blocks quickly.

4.2.15. SHP-Triplex pipe fittings supplied

The SHP-Triplex is supplied with the following 16 bar (160m) pipe fittings. We have used these fittings to test the SHP at up 30 bar (300m) and so far have never split a fitting but we have burst pipes (see right). These pipes were not rated for the head we were testing to.

Pressure ratings (working pressure) do include a good factor of safety and bursts are unlikely provided the water temperature is not too high.

If pumping to >16 bar (160m) the fittings supplied may not be suitable. Fittings and pipe approved for the operating pressure will need to be purchased with the pipes from a local supplier. Seek local supplier advice for higher pressure applications > 16 bar.



Hansen fittings supplied	Quantity	Picture
Fittings supplied for the pressure line		
Reducing Hex Nipple 20X10mm Black (HRHN2010) Pressure outlet from SHP	1	
Female Threaded Elbow 20mm Black (SE20) Direction change	1	
Male Straight Coupling 20mm Black (HMS20) To supply pipe	1	
Fittings supplied for the suction line		
Reducing Hex Nipple 20X15mm Black (HRHN2515) Suction inlet to SHP	1	
Female Threaded Elbow 25mm Black (SE25) Direction change	1	
25mm Hose Tail and Pipe Clamp To suction pipe		

Note: 10mm = 3/8” BSPT, 15mm = ½” BSPT, 20mm = ¾” BSPT, 25mm = 1” BSPT
Stainless steel fittings are available for heads >16 Bar (extra fee applies).

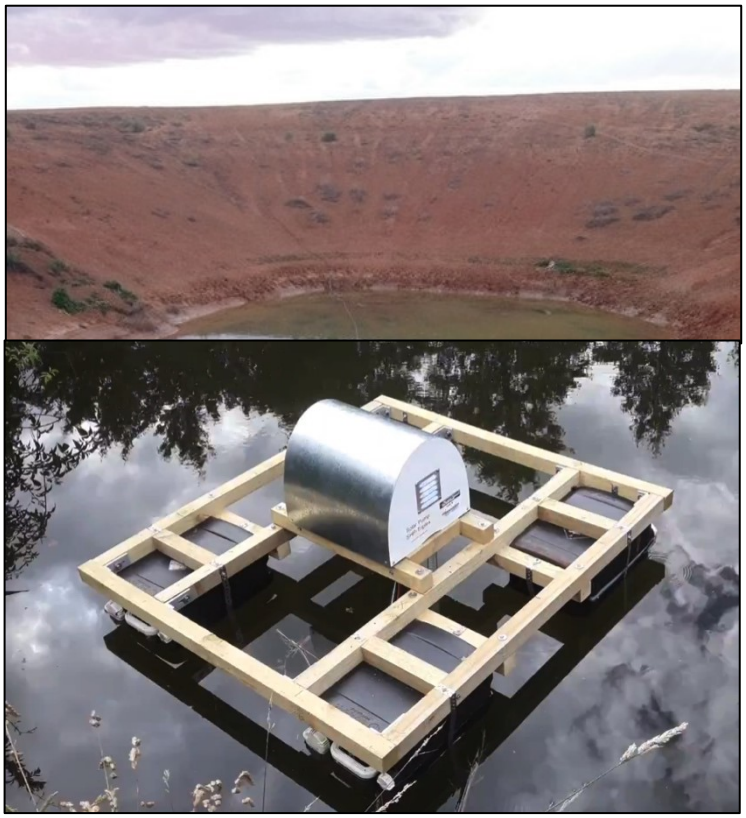
Fittings required for heads above 16 Bar are not provided as standard, customers will need to purchase locally following the advice of the pipe supplier.

All threads must be Teflon tapped.
The Hex Nipples have to be installed and tightened first, then the Threaded Elbows. Finally the Straight Couplings. If not done in this order the fittings will collide with each other as you attempt to tighten them.

5. Practical examples of installations

5.1. Pontoon pump system

In flat very dry countries that do not receive regular rain it is common to have very large dams for stock water which fill up every few years as rain allows. Australia is well known for years of drought followed by floods.



An SHP on a floating pontoon is an easy solution that makes sense because the SHP is light. Mounting the solar PV array on a larger pontoon also makes great sense.

A pontoon ensures a small and constant suction lift without danger of the pump being submersed by flood water.

The picture opposite shows a typical dam in Australia and a PowerSpout SHP on a small pontoon made from timber fence battens and 4 x 20 litre UV resistant plastic containers. A black plastic freight pallet also makes a great base for your SHP pontoon and these are common and often free.

Petrol/diesel pumps are often drowned in flood events as it is not practical to put them on a floating pontoon (as they need refuelling) and are heavy. If you fail to move petrol/diesel pumps quickly during heavy rain they can get drowned in the rising water.

Large petrol/diesel pumps are not well suited for smaller sized long PE pipes due to very high pipe friction losses. Some delivery pipes in Australia are over 20km long and nearly all the pumping head is due to pipe friction.

A smaller, solar-powered pump is the perfect answer, because it runs for long hours at lower flow rates. The SHP comes with a pressure sensor that can be used to turn off the pump when the header/storage tank is full.

SHP's are very light at <20kg and are easily separated from the pontoon. Each part is easy for 1 person to carry if the SHP needs to be moved to other dams on the farm.

The PV array is either fixed on level ground above the highest level of the dam or floats on a larger pontoon with the SHP. The waterproof double insulated 60-80V power cable can be sleeved in LDPE pipe if extra protection from damage is required.

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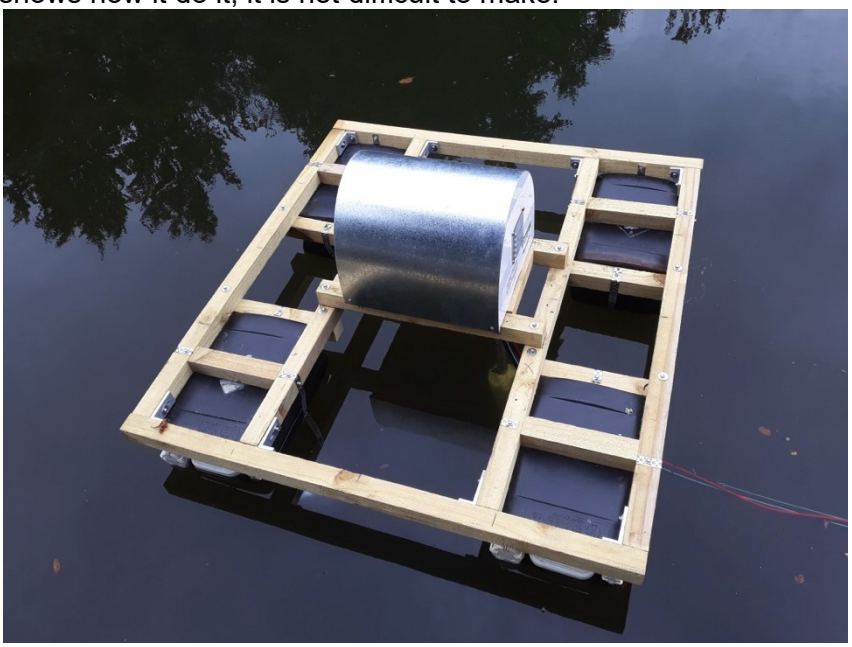
5.1.1. How to make a simple pontoon (1 x SHP's)

This pictures shows how it do it, it is not difficult to make.



The black floats are from 4 x 20 litre black (HDPE) containers that are good for >15 years in NZ's harsh UV sun. They are common on farms and easy to find on the surplus market for minimal cost.

The timber frame is made from ten 50 x 50 x 1200mm treated fence battens. Every NZ farm has these on hand. It is all held together with angled brackets and stainless tek screws. It took less than 1 hour to make at a cost of <$50NZ.

The four containers are held in place with perforated stainless straps as shown opposite. 8 small ratchet tie-downs could have also been used.

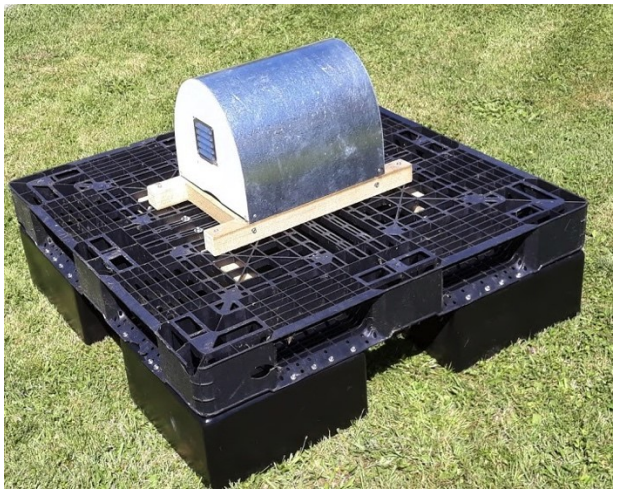
As a general rule the buoyancy of a 4 float pontoon (mass of water to fill floats) needs to be >2 times higher than the total mass. This it to ensure that should one float leak the pontoon will still float upright with the SHP above the water line. This will then be observed and the leaking float repaired or replaced.

Mass of pontoon & SHP	Mass of water to fill floats	Ratio
43 kg	88 kg	2.05

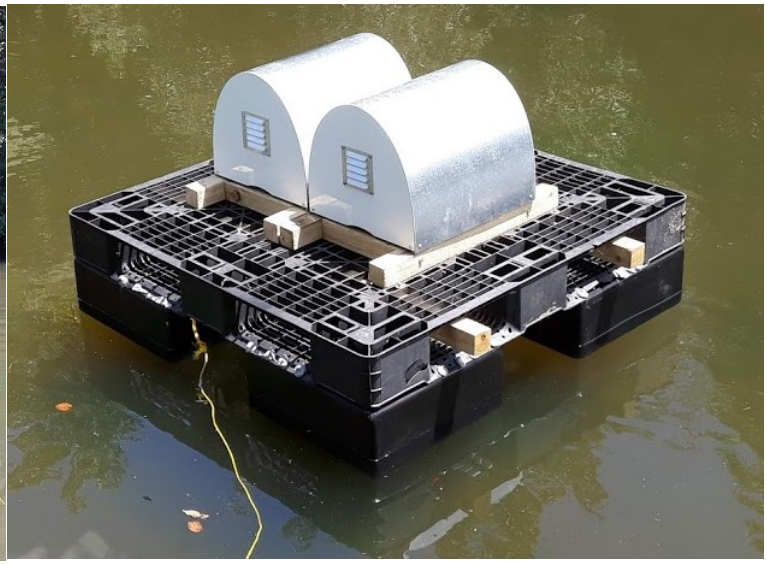
5.1.2. How to make a simple plastic pallet pontoon (1-2 x SHP's)

Using a surplus plastic black HDPE pallet is even faster to make a pontoon solution. This can be combined with the floats used in the previous example or (in the case of 2 x SHP's) with larger floats, both options are shown below.

These larger floats can hold 33kg of water (EcoInnovation can supply these floats to NZ clients only).



This took less than 20 minutes to make at a cost of <$200NZ (almost all the cost was the new floats) the plastic pallet was obtained for free.



Testing buoyancy of the pontoon prior to connecting: suction pipe, foot valve, filter sock, supply pipe and power cable

Mass of pontoon & 1 SHP	Mass of pontoon & 2 SHP's	Mass of water to fill floats	Ratio
45 kg	63 kg	132 kg	2.1

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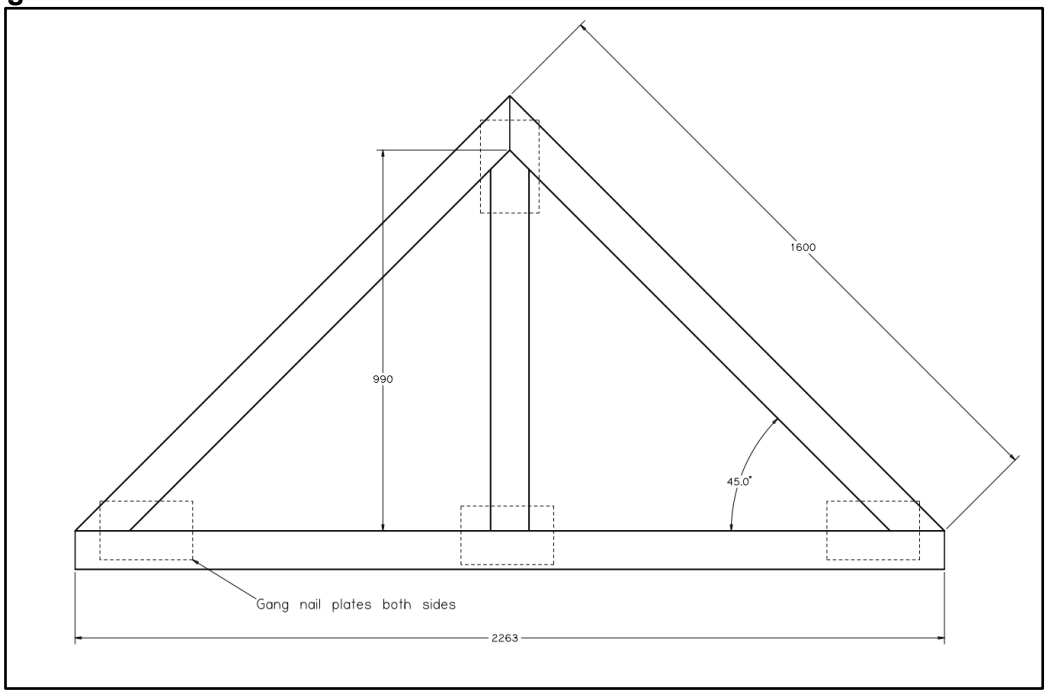
5.1.3. How to make a large pontoon for 1 x SHP and 540W or 1080W array

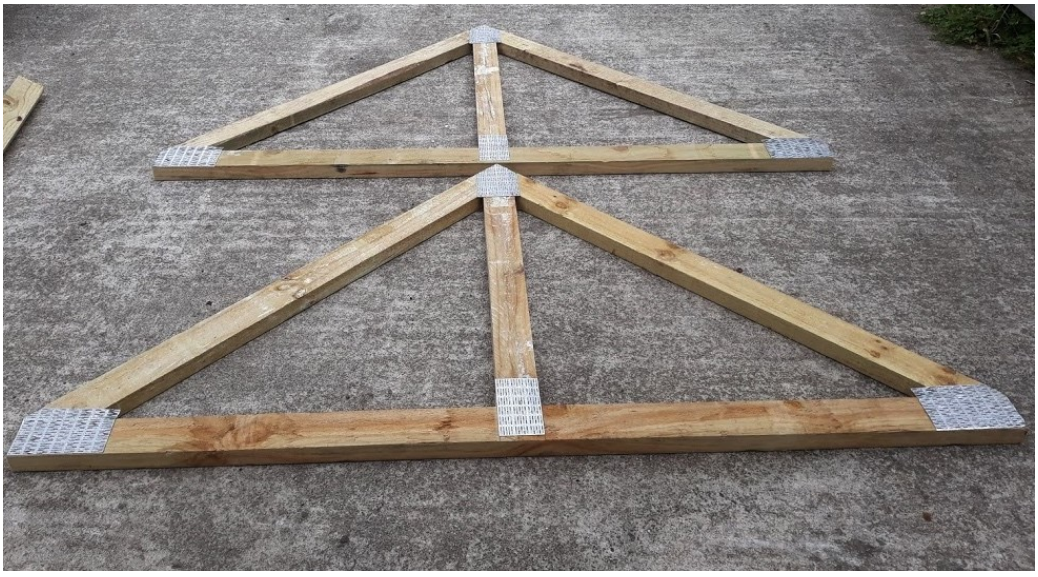
A large pontoon will take about 8-12 hours to make once all the parts have been secured. A truss is a very strong structure and easily made from treated timber. This truss solution can also be used for a land frame mounted on four (4) treated corner posts.

As there is much more wind loading once the PV is installed, such a pontoon will need to be secured with three (3) triangulated ropes and screw anchors good for 200kg each

Making the trusses



Make 2 trusses as shown from 100 x 50mm treated timber. You will also need 4 x 2m long 100 x 50mm treated timber purlins to connect the 2 trusses together as shown later.



Note the four 50 x 50 1200mm fence battens used for lateral bracing.
It is all held together with common tek screws, gang nail plates and angle brackets.

5.1.4. Making the pontoon

In this installation example we already had a pre-existing pontoon (made from 4 x 200 litre plastic drums) that has been used for the last 12 years as a floating bath and diving platform.

As you can see this works fine, the plastic drums are less than 40% submerged.
The trussed frame was then slid onto the pontoon and attached with angle brackets.
In this case the panels were attached to the timber frame with stainless steel builders strap.
Professional installers are more likely to use aluminium PV mounting rails to replace the timber rails. PV panel mounting is then faster but at higher material cost than illustrated above.

The pontoon was made as follows:

- 4 x 200 litre plastic drums.
- Treated timber frame that located each drum (made from 100x50 timbers).
- Two stainless steel wires at each drum end to secure them in place (made tight with turnbuckles). Ratchet tie-downs are also a good option.

Note our drums had a lip at each end that prevents the stainless wires from sliding off.
Locate this drum type if you can.

5.2. How to make a ground mounted 1080W array

A ground mounted East/West installation using the same trussed frame was then permanently installed close to our factory so that we can use it test each SHP-Triplex pump prior to sale.

All that is required are 4 large farm strainer posts securely mounted.
Strainer posts are H4 treated pine normally 150-200mm diameter in lengths 2.1, 2.4, 2.7 and 3.0m.

If you own a tractor mounter post hole rammer and the ground is suitable for rammed posts then this is a fast solution.

4 posts rammed 1.2m into firm ground will normally provide sufficient uplift restraint and lateral bracing for this structure not to work loose due to repeated wind loads.

Otherwise you can concrete in shorter posts at 1m deep with sufficient concrete mass to resist uplift forces.

If these foundation posts have any tendency to rock (or work loose over time) then diagonally brace them to each other. Structures higher off the ground (so that large animal cannot cause panel damage) will need bracing.

In our example we only have sheep in field and used 4 x 2.1m post concreted 900mm into the ground. There is good clearance under the trussed frame for the sheep to graze and seek shade on a hot summer days.

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5.2.1. Dig holes and position the 4 corner posts as shown

Posts are 2.1m long, 1.0m in the ground and dry mix concrete rammed to secure in place.

5.2.2. Position trussed frame

Bolt or use several long tek screws to secure truss at each post location.
The late afternoon shadow confirms the trussed frame is mounted East/West.

5.2.3. Aluminium rail mounting

To make the mounting of the PV panels quick and easy to do, we used short offcuts of aluminium mounting rails as shown. These offcuts can normally be purchased from PV install companies for $1/kg.
The PV panel fixing clamps fit into this rail.

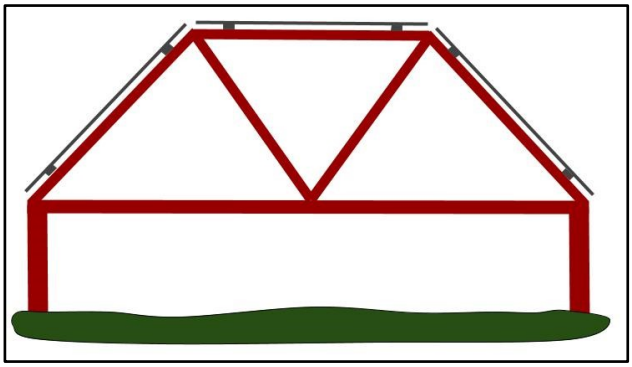
If you prefer, you can used 4 aluminium rails to replace the timbers rails completely but this will cost a little more to do.

Or you can secure the PV panels like we did in the pontoon example with stainless straps.

5.2.4. Completed East/West array

5.2.5. Arrays for East, Midday and West orientation with 6 panels

In a similar manner a larger array can also be mounted on low cost truss structure as shown opposite. Design advice for these larger trusses is beyond the scope of this guide. Seek local engineering advice



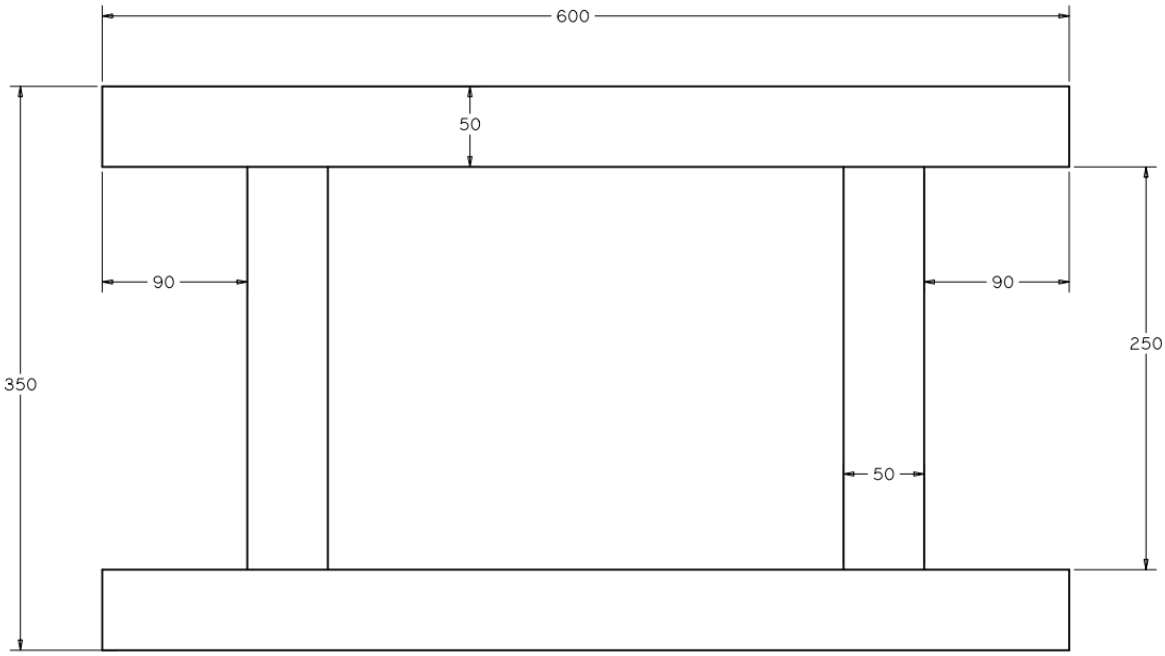
5.3. How to land mount the SHP-Triplex

If your water resource:

- does not easily allow for a pontoon solution
- has a suction lift <3m and is not prone to high flooding
- has a suction lift <6m, is not prone to high flooding and you are happy to manually prime the SHP
- is in a deep ravine and you intend to use a submersible lift pump

Then the instructions that follow illustrate how to install the SHP-Triplex on land.

SHP-Triplex base
You will need to make a treated timber base as shown below. NZ clients can buy this base if needed.



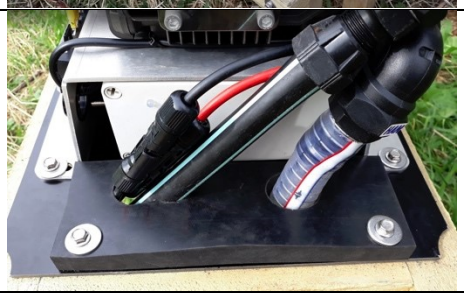
This SHP base is easy and quick to make from:

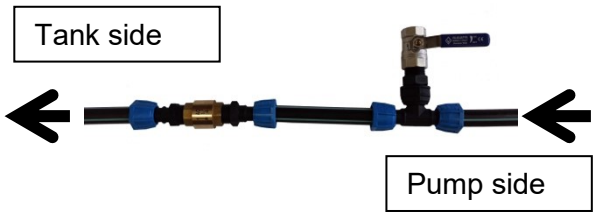
- 2 x 50x50x1200mm fence battens
- 4 x 100mm long stainless tek screws

The 90mm long arms are for mounting the base to 4 pegs as shown next.

5.3.1. Mounting SHP-Triplex base to support pegs

Drive Four 50 x 50 x 1200mm treated timber battens into the ground until firm using the base as a location guide as shown. The SHP will normally be some distance from the PV array on the other side of a stock proof fence and in closer proximity to the water resource. The pictures that follow are from the construction of our SHP test base where each SHP is tested prior to boxing and final despatch.	
Mark a level line at 400mm above ground height.	
Cut battens to height.	
Pilot drill holes and attach SHP base with 100mm long stainless tek screws while ensuring it is all level.	

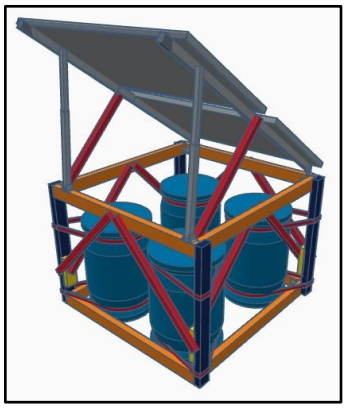
Attach SHP white base as shown with 2 x 25mm stainless teks. (Production models sold after March 2019 will have black bases.)	
Attach SHP aluminium base as shown with 4 x 50mm stainless teks.	
Check pump cover fits. These covers are made from stainless steel sheet on production models. Pump cover is held in place for safety and weather tightness (it is a rotating machine) with a tie-down as shown. We can now remove the fairing and proceed to connect the wires and pipes that follow.	
Pipe and cables correctly installed, note the rubber vermin guard has been cut and fitted in place. These heavy rubber pads are only provided for NZ clients.	

Final plumbing connections after SHP-Triplex: • Bypass valve • Week link • One-way valve	

5.3.2. Where ground foundations are not possible

If at your site the ground is too rocky for ground post foundations then you can consider 4 x 200 litre plastic drums filled with water (common surplus items on farms) secured to each corner of your frame with two ratchet tie-downs (as shown) to prevent the wind from blowing over the frames. For high wind sites fit and secure a fifth drum in the centre position.

You can also use old plastic (or steel) drums. Fill them will local rocks and concrete. These very heavy drums then become the corner foundation masses for your structure.
You may want to position a timber or steel post in the middle of the drum (while it is packed with rocks and concrete) to provide a location point for the frame or truss that will carry your PV array(s). You can use the truss method for an East/West array as detailed earlier.



6. Pipe size selection

PE pipes are the obvious choice for the PowerSpout SHP's (and to protect the solar PV wires) because of the range of available sizes, pressure ratings and lengths and the fact that they are durable, low cost and commonly available.

6.1. Selecting suitable delivery pipes (from SHP to tank)

Pipe friction (depending on both the flow rate and pipe size) will add to the static pressure resulting in a higher "dynamic head" at the SHP. Dynamic head is the sum of the vertical height (static head) and the friction head (due to pipe friction). Your SHP will self-optimised to produce maximum flow under the conditions it sees as it comes with electronic maximum power point tracking (MPPT). If more power is available the pump speed is increased, less power the speed is decreased.

If you get your dynamic head calculations grossly wrong, and you calculate 100m and then get 160m pressure instead, it is possible that your supply pipe will bust (although there is some safety factor for the working pressure rating). You will have installed 12 Bar pipe when 16 Bar was required. Such an error will not damage the SHP as it can operate to 300m head. But pumping flow performance in marginal solar conditions will suffer.

Start by measuring:

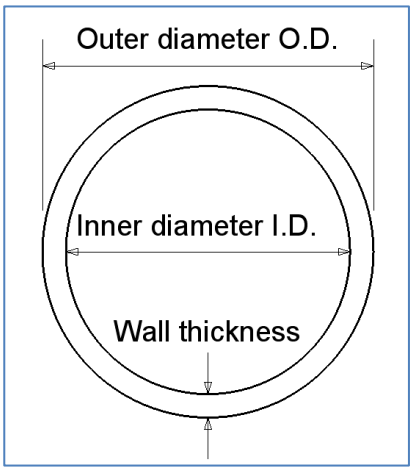
- the suction lift at your site from water surface up to SHP centre (is it less than 3m?).
- the lengths of your suction and delivery pipes.
- the height of your header storage tank above the SHP (static head).

Based on the tables provided in this document you will need to select, purchase and install the correct suction and delivery pipe sizes. Your supplier (and/or Ecoinnovation) will be happy to help you with this. If in doubt always go up a size to keep your options open for more future pumping capacity. Pipes will also foul over time with fine sediments and this can greatly increase the pipe friction head on long pipe runs over time.

Every site is different, so the design process is worth doing, and the measurement of head is key. However, if you get your site data wrong, the SHP pump will work just fine so long as your pipe does not burst.

6.1.1. The difference between internal and outer diameter

Inside diameter is critical for calculation of pipe friction loss since a variation of as little as 1mm can have a very significant effect on the headloss, which increases the dynamic head and hence reduces the output flow of the SHP. Your pipe can rupture if you make a gross error in pressure calculation.



A given pipe size based on "outer diameter" OD is often available in a number of pressure ratings and the actual "inner Diameters" IDs will not be the same. Pipes that have the same OD but different IDs due to differing wall thickness are referred to as being in the same NB (nominal bore) size classification. Bore means inner diameter but nominal bore is the not the same as actual ID.

But you need to find out the exact ID of your pipe because this will determine the head loss.

6.1.2. Quick guide to finding the best pipe with a single SHP

You need to know rough figures for your vertical rise (static head), and your pipe length.

1. Find the entry on the left that is closest to your static head.
   (For example if your head is between 63-104m then choose 83m).
2. Find a pipe size (Internal diameter!) that you can buy in the yellow box. (Say 25mm.)
   (If you are using two SHPs then choose one of the larger green pipe sizes instead.)
   Ask your pipe supplier for a list of specifications (see examples below), with diameter, wall thickness and pressure rating.
3. Based on your chosen row for the head, and the column for the pipe size, find the pipe length for 20% loss (83m and 25mm pipe gives 1040m)
4. If your pipe is shorter than this length, your loss will probably be under 20%, so this internal diameter choice will be fine. If your pipe is longer then consider using a larger pipe size.

Choosing a suitable		Pipe lengths with 20% pressure loss (longer pipes will have more than 20%)											
Internal Diameter		Pipe IDs for single SHP pump											
Vertical	Peak flow	19mm	20mm	21mm	22mm	23mm	24mm	25mm	26mm	27mm	28mm	29mm	30mm
rise or	per pump	Pipe IDs for twin SHP pumps flow											
Static head	approx.	25mm	26mm	27mm	29mm	30mm	31mm	33mm	34mm	35mm	36mm	38mm	39mm
42m	16 l/min	128m	163m	208m	260m	321m	397m	463m	556m	694m	833m	926m	1190m
83m	15 l/min	287m	370m	463m	575m	725m	877m	1042m	1282m	1515m	1852m	2083m	2381m
125m	15 l/min	431m	556m	694m	862m	1087m	1316m	1563m	1923m	2273m	2778m	3125m	3571m
167m	14 l/min	654m	833m	1042m	1282m	1587m	1961m	2381m	2778m	3333m	4167m	4762m	5556m
208m	13 l/min	926m	1190m	1488m	1894m	2315m	2778m	3472m	4167m	4630m	5952m	6944m	8333m
250m	12 l/min	1282m	1613m	2083m	2500m	3125m	3846m	4545m	5556m	7143m	8333m	10000m	12500m

If the pipe cost is low, then err on the side of using larger pipe, to reduce losses.
If the pipe cost is a large part of the project budget then you may wish to tolerate higher losses to reduce pipe cost.

6.1.3. Pipes commonly available from Rural Direct in NZ

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

The above table will assist you with commonly available pipe ID sizes in NZ.
Pipe with pressure ratings up to 160m and higher are available, but not as common.

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6.1.4. The IPLEX pipe range of LDPE/MDPE/HDPE pipes

This is the IPLEX pipe range. Pressure ratings are 60, 90, 125,160, 200 & 250m rated.

		Greenline (370 Series)		Redline™ (360 Series)		Rural Black (340 Series)		BlacklinePN16 (3500 BTS Series)		BlacklineHPPN20 (3500 B Series)		BlacklineHPPN25 (3500 B Series)	
		Bar	PSI	Bar	PSI	Bar	PSI	Bar	PSI	Bar	PSI	Bar	PSI
Pressure Rating *	20	9	131	12.5	182	✗	✗	✗	✗	✗	✗	✗	✗
	25	8	116	12.5	182	✗	✗	16	233	✗	✗	✗	✗
	32	8	116	9	131	12.5	182	16	233	✗	✗	✗	✗
	40	6.3	91	9	131	12.5	182	16	233	✗	✗	✗	✗
	50	6.3	91	9	131	12.5	182	16	233	✗	✗	✗	✗
	63	6.3	91	9	131	12.5	182	16	233	20	291	25	364
	75	✗	✗	✗	✗	12.5	182	✗	✗	✗	✗	✗	✗
	90	✗	✗	✗	✗	12.5	182	16	233	20	291	25	364
	110	✗	✗	✗	✗	12.5	182	16	233	20	291	25	364

Iplex approx. pipes **costs:**

- Redline 125m rated 25mmOD (20NB) pipe $1.94 NZ/m
- Redline 90m rated 32mmOD (25NB) pipe $2.04 NZ/m
- Redline 90m rated 40mmOD (35NB) pipe $2.69 NZ/m

6.2. Example of the full calculation to predict pressure loss at a higher accuracy

The example that follows will help you to work out in detail a suitable pipe size for a system that uses just one SHP per pipe. We have a pipe efficiency target of 20% friction loss at peak flow as a starting point.

Remember that you can vary the pipe pressure rating along the length of the run to minimise costs. For example, if you have a 160m delivery head you start with high grade (16 bar) pipe at the SHP, 12 bar, then 9 bar and finally 6 bar. Laying 16 bar pipe all the way can almost double the cost of the supply pipeline to your tank. You can use the table below to calculate the friction head ("head loss") in your pipe for a given pipe ID.

Site data (Northland NZ):

- Lift to tank 80m (plus 2m height of tank =82m) + 20% for pipe friction = 98.4m.
- Distance 1000m.
- Summer flow requirement less than 5,000 litres/day.
- Grade is relatively constant.
- Initially assume pipe friction head = 20%.

From the peak flow table (right) at 100m head the SHP can do 15 L/min (round to nearest L/min)

The table on the next page tells us how much pressure will be lost per 100m of pipe run.

Head	Peak L/min
50	15.79
100	15.24
150	14.56
200	13.81
250	13.10
300	12.40

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6.2.1. Head loss in m per 100m length of new smooth bore plastic pipe

Flow l/min	Smooth new plastic pipe ID in mm																					
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
10	2.9	2.2	1.8	1.4	1.2	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
11	3.4	2.6	2.1	1.7	1.4	1.1	0.9	0.8	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
12	3.9	3.1	2.4	2.0	1.6	1.3	1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
13	4.5	3.5	2.8	2.2	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1
14	5.1	4.0	3.2	2.6	2.1	1.7	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1
15	5.8	4.5	3.6	2.9	2.3	1.9	1.6	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
16	6.5	5.1	4.0	3.2	2.6	2.1	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2
17	7.2	5.7	4.5	3.6	2.9	2.4	2.0	1.6	1.4	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.3	0.3	0.2	0.2
18	8.0	6.3	5.0	4.0	3.2	2.6	2.2	1.8	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.2
19	8.8	6.9	5.5	4.4	3.5	2.9	2.4	2.0	1.7	1.4	1.2	1.0	0.9	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.3
20	9.6	7.5	6.0	4.8	3.9	3.2	2.6	2.2	1.8	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3
21	10.4	8.2	6.5	5.2	4.2	3.4	2.8	2.4	2.0	1.7	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.3
22	11.3	8.9	7.0	5.6	4.6	3.7	3.1	2.6	2.1	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.5	0.5	0.4	0.4	0.3
23	12.2	9.6	7.6	6.1	4.9	4.0	3.3	2.8	2.3	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4
24	13.2	10.3	8.2	6.6	5.3	4.4	3.6	3.0	2.5	2.1	1.8	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.4	0.4
25	14.2	11.1	8.8	7.1	5.7	4.7	3.8	3.2	2.7	2.2	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4
26	15.2	11.9	9.4	7.6	6.1	5.0	4.1	3.4	2.9	2.4	2.0	1.7	1.5	1.3	1.1	1.0	0.8	0.7	0.6	0.6	0.5	0.4
27	16.2	12.7	10.1	8.1	6.5	5.3	4.4	3.7	3.1	2.6	2.2	1.9	1.6	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.5
28	17.3	13.5	10.7	8.6	7.0	5.7	4.7	3.9	3.3	2.7	2.3	2.0	1.7	1.5	1.3	1.1	0.9	0.8	0.7	0.6	0.6	0.5
29	18.4	14.4	11.4	9.2	7.4	6.1	5.0	4.1	3.5	2.9	2.5	2.1	1.8	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.5
30	19.5	15.3	12.1	9.7	7.9	6.4	5.3	4.4	3.7	3.1	2.6	2.2	1.9	1.6	1.4	1.2	1.1	0.9	0.8	0.7	0.6	0.6

(The table above is sufficient for sizing pipe systems with 1-2 SHP's installed. For larger SHP installs seek manufacturer advice.)

We only have 2 options we can buy: pipe with ID just over 20mm (20NB) and those just over 25mm (25NB).

Let's consider them both. Looking at the above table, for every 100m of 20mm ID pipe at 15l/min we have 4.5m of extra friction head. Can you locate the 4.5m on the table above? When you can find this figure at the intersection of the 15 L/min row and the 20mm ID column, then proceed to read what follows.

- Dynamic head on 20mm pipe = 82 + 10x4.5 = 127m
- Dynamic head on 25mm pipe = 82 + 10x1.6 = 98m

We first decide to use 25NB (from Rural Direct) pipe that has a common 32mm OD. This comes in 3 grades suitable for our site: 65m (25mm ID), 90m (28mm ID) and 125m (27mm ID) rated. The lower pressure ratings are fine for the upper stretches of pipe.

25NB pipe example

Pipe needed	Pipe ID mm	Friction head per 100m roll	Total
2 x 200m rolls of 125m rated pipe	27mm MDPE	1.1m	4.4m
2 x 200m rolls of 90m rated pipe	28mm MDPE	0.9m	3.6m
1 x 200m roll of 65m rated pipe	25mm LDPE	1.6m	3.2m
		pipe friction head	11.2m

So the calculated head is 82m static lift + 11.2m pipe friction head = **93.2m**. Headloss is about 14%, this is less than the 20% we initially allowed for so all is well. If it was over 20% we would need to go up another pipe size.

Let us now look at a 20NB pipe example for comparison

Pipe needed	Pipe ID mm	Friction head per 100m roll	Total
2 x 200m roll of 125m rated pipe	21mm MDPE	3.6m	4.4m
2 x 200m rolls of 90m rated pipe	22mm MDPE	2.9m	3.6m
1 x 200m rolls of 80m rated pipe	20mm LDPE	4.5m	3.2m
		Pipe friction head	35m

So the calculated head is 82m static lift + 35m pipe friction head = **117m**. Headloss for 20mm pipe is about 42%

The reality is that pumping to 93.2m or 117m would not make a large difference in the L/day yield for the following reasons:

- Pipe flow will rarely be at 15L/min (so friction head is less in reality), this reduces the dynamic head on the smaller pipe to a greater extent than the larger pipe.
- Pump is more efficient on higher lifts.

So in the end it all depends on the relative pipe cost while taking account of the fact that pipes will higher losses may require a higher pressure rating. If the quote for the 1000m of 20NB pipe is much less than the 25NB pipe then maybe go for the cheapest option. If there is say less than 20% in it go for the larger pipe. The larger pipe does keep your future options open.

If in doubt (and funds are available) we would always recommend using a larger pipe size, given that pipes will become fouled over time and so the headloss will increase. A decision must be made based on:

- the required flow rate
- the relative costs of pipe at the calculated dynamic pressure
- your future options

6.2.2. Onsite flow test (25 NB)

On a typical day at midday in January we measured 20 litres in 80s = 15 l/min

Here is the pressure gauge (25NB pipe example):

- Dynamic pressure = 980kP = 100m (calculated 82+11.2 = 98.2m)
- Static pressure = 820kPa= 82m

The initial static head estimate by the client was very close, dynamic pressure ended up as 100m @ 15 L/min in agreement with the calculations.

6.3. The Suction (intake) Pipe

Suction head must **not exceed** 3 metres if you want the SHP to self-prime (with an empty delivery pipe), otherwise it must be less than 6m with manual priming assistance.

Gravity feed is best if possible (no suction at all). See the next section for intake design and SHP priming issues in detail.

Multiple SHP's can share the same suction line but only if the water can gravity feed to the SHP's. Otherwise every SHP at the same site should be fitted with its own separate suction hose and foot valve to ensure a high reliability factor.

We supply with each SHP system in NZ with a 5m length of 25mm ID clear suction hose and foot valve. Where possible use a clear suction pipe, so you can observe:

- Water in the pipe.
- Air bubbles that may indicate a leaking joint, pinhole in the pipe or cavitation.
- Growths in the pipe such a snails and algae (clean or replace the suction hose as needed).

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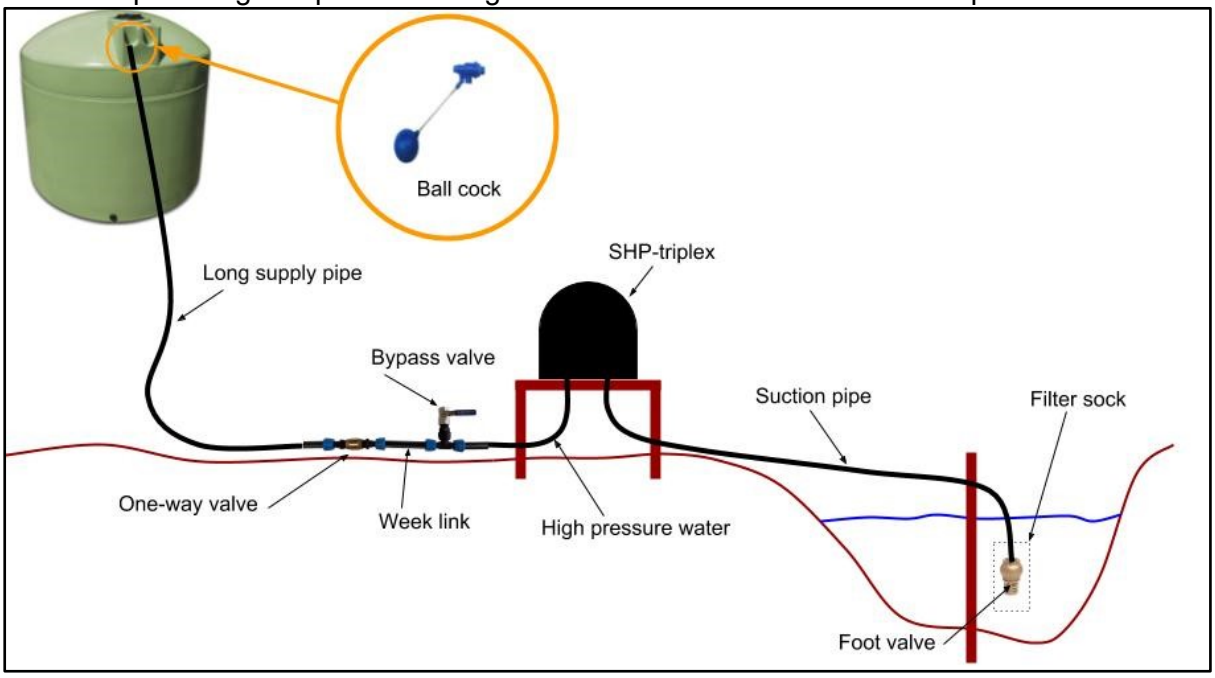
7. Commissioning the system

7.1. Installation plumbing of the SHP-Triplex

The main plumbing components of a good installation are described in the picture below.



The key points to a good SHP installation are as follows:

- Keep the SHP as low as possible to allow for gravity feed or to keep the suction lift as low as possible.
- Ensure (for a ground mounted SHP) there is at least a 300mm under the SHP for pipes and cables to enter via the bottom opening.
- Ensure that vegetation is prevented from growing into the SHP and clogging the vents. (Cover the area under the SHP motor with concrete or corrugated steel.)
- Secure the SHP to the ground with steel or timber pegs (not provided as most NZ farms will have suitable materials on hand).
- Protect all ELV wires in suitable conduit if they are likely to be damaged.
- Protect the SHP from animal damage with an electric fence and/or pump shed.
- In fire risk areas, mount on a concrete base and cover with a vented metal fire enclosure.
- Seal all threads with sealing tapes, compounds or seating washers to ensure no leaks.
- Fill the pump body with clean SAE20W/30 oil or any similar quality general-purpose multi-grade engine oil to middle of the indicator glass.
- Secure pipes and cable with saddles and cable ties as needed.
- Check the PV switch is in the off position (as shown) and then connect the SHP MC4s to the PV wires from the switch.

7.2. SHP Components

In order to reduce the length of this installation manual the parts list and instructions on how to service and assemble the SHP are in a separate document that will be available from 2019.

NEVER work on your SHP while it is in operation.

7.2.1. SHP Protection

SHPs arrive fully assembled, other than oil.
The PowerSpout SHP is encased in a durable housing, ensuring all internal parts are protected from rain, rodents, children and UV etc.

7.3. Commissioning procedures

7.3.1. Checks with cover off - before start-up

These tests ensure you have completed the plumbing connections and have no leaks.
By this stage you should have:

- Installed the suction (foot valve and filter sock) or a gravity feed intake.
- Securely attached the SHP to a suitable base.
- Connected SHP suction and delivery pipes.
- Connected the delivery pipe to the tank with a ball cock fitted (inside the tank) if you want to SHP to turn off when full.
- Filled the SHP with oil.
- Manually primed the SHP suction line if required (if suction head exceeds 3m).
- Ensure the on/off switch on the BLDC is on.
- Secured all protective fairings.

7.3.2. Commissioning the SHP

Check that there is sufficient sunlight for the solar panels to provide adequate power. Turn the SHP on at the switch. Provided you have good sunshine on the panels the SHP will start to rotate. It will spin fast at first, and there should be little noise. As the delivery pipe fills with water and the backpressure builds up, the SHP will steadily slow in speed. While the pipe is filling keep an eye on the SHP pipefittings for any leaks. Turn off and fix them if observed.

If the delivery pipe is already filled with water following an SHP service (for example). You will need to open the bypass valve for air to purge from the SHP. After 15-30s of observed water flow this valve can be closed.

Once the sun gets too low in the sky there is not sufficient power for the pump to continue to work and it will stop. It may still attempt to start (clicking noises) but will in due course stop completely. Likewise, on sunrise the pump will attempt to start and in due course will run continuously increasing speed with sun intensity.

7.3.3. Trouble shooting commissioning problems

Each and every SHP is tested on our test rig at a 160m working head of pressure. If it has been correctly installed but fails to operate then these are the likely causes:

- SHP was damaged in freight.

- Wrong size and/or voltage PV panels have been used (by clients who purchased the PV panels themselves).
- Your solar radiation level is too low because of the weather, you live close to the poles or it is night time.
- You did not push the MC4 crimped metal components into their plastic housings until they clicked. They need to be pushed fully home or else the electrical connection can be compromised.
- Main switch or BLDC "ignition" switch is turned off.
- You fitted a float level switch incorrectly. Attach such switches after initial commission has been completed so you have less potential problems to deal with.

See next page for a table of problems and suggested solutions.

7.4. Commissioning checks

It is important to formally commission the SHP and associated system to ensure it is working correctly prior to leaving the site for the day. It may take another day on site to test everything because by the time you have completed the SHP installation the sun may be too low in the sky to test correct operation.

7.4.1. Operating checks

- Check that the intake is submerged or has surplus overflow water.
- Check for any leaks on the delivery pipe and fittings.
- Check for any leaks on the suction pipe and fitting (visible air bubbles).
- Check for any excessive vibrations.
- Check flow to your tank is in the expected range for the sunlight conditions and time of year.
- Check and adjust the operation of any float switches or pressure settings.

7.5. Record the facts!

Please now fill out the form at the end of this document for future reference.

Problem	Check
SHP does not start.	Is it daytime? It will not start with poor light. Is the solar panel switch turned on? Is BLDC switch turned on? Is the tank full and the pressure sensor has told the pump to wait (blue LED will flash)
SHP stops and starts every 20s.	There is not enough light to run. Wait for more sun. It should then start and run fine.
SHP stops when sun goes behind a cloud but then restarts at a lower speed.	This is normal, all is well. Power level can be too low at times for it to run
SHP is spinning quickly but no water is being pumped.	Prime the SHP manually if necessary. Check suction line hose clamps for leaks. Check foot valve/intake is still under water. If you cannot resolve the issue turn off the SHP and seek assistance.
Suction head is more than 6m and the SHP will not hold prime, what do I do?	Modify your site to have less suction head by lowering the SHP to be closer to the water resource. Fit the SHP on a floating pontoon if possible or fit a submersible lift pump.
The SHP is dead. It was running fine and none of the issues listed above are the problem.	In NZ return to EcoInnovation for repair/service. International clients contact your dealer who will contact us for advice.
SHP went under water in a flood and no longer works.	In NZ return to EcoInnovation for repair/service. International clients contact your dealer who will contact us for advice.
I started to install an SHP but have realised that I do not have the skills to complete the job. I am not a very practical and have an aversion to all things electrical?	In NZ ask EcoInnovation to quote you to do the installation. International clients contact your dealer for advice or book an online consultation:
I have installed it exactly as per the manual but it does not work, can you help?	In NZ ask EcoInnovation to quote you to visit the site and commission it for you. Or you can return the SHP for to us to test operation again. If the unit has been damaged by overvoltage then it will have to be returned for repair. Note this can only happen if all panels are connected together in series and not as advised in this document. If you did in your haste connect all panels in series then the BLDC and microprocessor will have been ruined and you will need a new one. International clients please contact your dealer for advice.
I got the wires from the switch box to the SHP the wrong way around, and after correcting this mistake the SHP will not work.	In NZ return to EcoInnovation for repair/service. International clients contact your dealer for advice. The BLDC and microprocessor will have be ruined and you will need a new one

7.5.1. Documentation as per AS/NZS 5033

The PV system installer shall prepare the following documents and a copy shall be provided to the PV system owner:

(a) A list of equipment supplied.

(b) A list of actions to be taken in the event of an earth fault alarm.

(c) The shutdown and isolation procedure for emergency and maintenance.

(d) A basic connection diagram that includes the electrical ratings of the PV array, and the ratings of all overcurrent devices and switches as installed.

(e) System performance estimate.

(f) Recommended maintenance for the system.

(g) Maintenance procedure and timetable.

(h) The commissioning sheet and installation checklist.

(i) Array frame engineering certificate for wind and mechanical loading.

(j) Installer/designer's declaration of compliance declaration to Clause 2.2.

(k) Warranty information.

(l) Equipment manufacturer's documentation and handbooks for all equipment supplied.

(b) is not relevant for ELV systems in NZ

Note the "PV system installer" is the farmer/owner if they install it themselves. The above is a mandatory requirement for LV systems. As your system is ELV the above can be regarded as good practice. To comply with good practices the installer shall prepare and retain these documents. This manual meets all the above requirements.

7.5.2. Labelling for disconnection devices as per AS/NZS 5033

5.5.2 PV array disconnecting device

The PV array d.c. switch-disconnector shall be provided with a sign affixed in a prominent location with the following text:

PV ARRAY D.C. ISOLATOR

Where multiple isolation/disconnection devices are used that are not ganged (refer to Clause 4.4.1.3) signage, stating:

WARNING: MULTIPLE D.C. SOURCES

TURN OFF ALL D.C. ISOLATORS TO ISOLATE EQUIPMENT

shall be placed adjacent to the PCE.

The sign shall be black lettering on a yellow background.

The sign below is provided on the cover of the switch enclosure

7.5.3. Advised periodic maintenance NZS 5033 (these are advised only)

C2 PERIODIC MAINTENANCE

The following maintenance activities should be considered for inclusion in the maintenance procedures, according to the location, size and design of the PV array:

(a) Safety warnings and manufacturer's recommendations.

(b) Cleaning of the PV array might be periodically required in locations where it is likely to collect dust or other shading materials.

(c) Periodic inspections should be carried out to check wiring integrity, electrical connections, corrosion and mechanical protection of wiring.

(d) Verify open circuit voltage and short circuit current values.

(e) Verify functioning of earth fault protection (if relevant).

(f) Verify operation of tracking systems (if relevant).

(g) Measure I-V characteristics (if possible).

(h) Perform seasonal PV array tilt adjustment (if relevant).

(i) Check PV array mounting structure(s).

(j) Test operation of switches regularly.

(k) Check for module defects (fracture, moisture penetration, browning, etc.).

(l) Verify status of surge arrestors (if relevant).

(m) Infrared scans can be of use in identifying problems.

A sample maintenance schedule is shown in Table C1.

e,f,g,h,l & m are not relevant to this SHP ELV installation

7.6. Feedback

We welcome your constructive feedback on how we can improve our products, including this manual. Any emails or Facebook posts that contain rude, offensive or abusive language will not be replied to.

8. Operation and maintenance

8.1. Starting and stopping

The pump will not start unless the switch at the solar array and the ignition switch on the BLDC driver are both on. If you have connected any float switch(s) make sure you have enough water and they are correctly installed or they may prevent operation of the SHP.

The pump will start, increase speed, decrease speed and stop, all automatically based on available light at the solar PV arrays. The pump can be manually stopped either by breaking the ignition switch circuit, or by turning off the main DC switch at the solar array or BLDC.

8.2. Priming

Possible Priming Issues Table

	Gravity feed on suction line	Low lift on suction line (under 3m)	Higher lift on suction line (over 6.0m)
Empty delivery pipe Empty suction pipe	N/A	Will self-prime ☺	Will not self-prime. Manual prime
Full delivery pipe Empty suction pipe	N/A	Will self-prime if you open the bypass valve to allow air to flush out.	Will not self-prime. Manual prime.
Empty delivery pipe Full suction pipe	Excellent ☺ (Will run fast for a while)	Very good ☺ (Will run fast for a while)	Good ☺ (Will run fast for a while)
Full delivery pipe Full suction pipe	Excellent ☺	Good ☺	OK if foot valve and filter sock always in good & clean condition

Green denotes normal operation once all pipes are primed, as should be the case on each sunrise following initial commissioning.

8.2.1. Manually Priming the SHP

In theory, it should be possible to suck water from a depth of 10.33 metres, however, this would require an absolute vacuum. In practice, the maximum is much lower and typically 6 metres if you want to avoid loss of suction issues on a regular basis.

To prime (suction lifts >3m):

- Turn SHP off
- Open the bypass valve (so air can purge out)
- Remove priming cap. You need to install a vertical riser on the suction line to do this
- Fill suction pipe as shown
- Replace priming cap
- Start SHP
- Once the exhaust water flow and suction pipe is running free of air bubbles close bypass valve

Let it run for say 15 minutes then turn it off and watch the water in your clear suction line. If is starts to drain back slowly (with air taking its place) you have a leak. Check your fittings are tight and that the hose clamps are tight and well seated. Any leaks will result in loss of prime, your SHP will not then be able to reprime and will just spin unloaded with likely damage in due course. If you are happy that all is good then leave the SHP on and return in

the morning to check you still have prime and the SHP is pumping as expected, then all is good :)

8.2.1. Changing a foot valve:

Always change a foot valve on a day when you have good sun and space in the header tank for water so your pump is able to run. If your tank is full and you have a blinking blue LED you can run it by opening the bypass valve and restarting the pump via the ignition switch.

Turn off the SHP at the ignition switch, replace the old foot valve and filter sock with a new one. Start the SHP and open the bypass valve to allow air in the suction line to clear. Close the bypass valve. Check the suction hose and fittings for any leaks and repair as required. If head is above 3m then you may also need to prime the suction pipe manually

8.3. Particular points to monitor

Ensure that rodents cannot get access inside the pump. Ensure that grass and other vegetation is prevented from growing into the pump via the cooling vents. Cover the ground with corrugated steel or concrete to prevent plant growth if required.

8.3.1. Oil

Do not intentionally run the pump without first adding oil.
Fill the pump body with clean SAE20W/30 oil or any similar quality general-purpose multi-grade engine oil to the top of the rear oil level indicator glass. If you over fill the oil level drain some out before starting. Oil level should never be less than the bottom edge of the level glass or more than the top edge.

8.3.2. Operating conditions

Do not intentionally run the pump without a water supply.
In a pump runaway situation (where output pipe bursts), turn off the solar PV DC switch to stop the SHP.

8.3.3. Rapid pump deceleration

In certain light conditions you may observe rapid pump deceleration and the motor coming to a complete stop and then restarting. This can happen when the sun rapidly disappears behind a cloud so that available power reduces quickly. The pump must decelerate quickly, but its inertia delays this and the voltage of the PV array crashes below the BLDC re-set voltage. Hence the motor stops, then the voltage recovers and the BLDC does a motor restart. This is normal behaviour in certain light conditions, it does not make any great difference to the amount of water pumped but may appear unusual if you have not been warned to expect this at times. In overcast diffused light (or blue sky) conditions you will not observe this behaviour as solar radiation levels are more constant and not subject to rapid changes. **Note the pump will slow (or stop at times) every 10 minutes as part of its internal Maximum Power Point Tracking (MPPT) optimisation checks.**

8.3.4. Advice on freezing

A frozen brass head on the SHP could result in serious damage that could cost up to 30% of the new SHP-Triplex to repair. A frozen pipe should not be an issue as the SHP-Triplex will see a pressure rise and stop (provided this feature was enabled).

It is difficult to prevent freezing on sites where there is no power available at the time. Even though we can detect freezing temperatures (after sunrise) the damage will have already been done.

As the SHP-Triplex is intended for high lifts using long pipe on farms we are of the view that winter time water pumping needs will be minimal or not required at all.

This is our advice:

Areas with occasional frosts no lower than -3°C

- Pontoon mounted – no freezing protection needed.
- Land mounted – install small secondary cover over the SHP at the time of year when frost can be expected.

Areas with heavy frost no lower than -6°C

- Pontoon mounted – no freezing protection needed provided water surface never freezes.
- Land mounted – Install SHP on an insulated concrete pad, fit small insulated cover over SHP and pad. An old chest freezer makes a great small insulated building. This enclosure does need venting as the SHP makes some heat. Only fit the insulated cover at times of the year when it is needed to prevent frost.

Areas with temperatures lower than -6°C

- SHP not needed in winter time – disconnect suction and supply pipes, run it for 10 seconds so water can clear the plunger chamber. Turn off the solar power. Wrap the SHP in an old wool blanket. Put cover over SHP (an old freezer body would make a good cover) and do not restart until minimum night time temperatures are higher -6°C
- Seek engineer's advice on the design of an insulated building and the laying of your pipes to prevent freezing. An old chest freezer makes a great small insulated building, but this does not help to prevent the long pipes from freezing. This level of detail is beyond the scope of this document.

8.4. Regular checks

The PowerSpout SHP is a durable machine but can run for 1000s of hours each year, so regular checks and maintenance are advised. A PowerSpout SHP-Triplex may do more revolutions in 5 years than a car engine during the life of the car. A car engine has a filtered and pumped oil lubrication system, whereas an SHP does not.

To maintain your SHP in a good condition for years to come we recommend you keep a log book and make the following checks:

<u>Every month initially, and once you become familiar with your system every 3 months:</u>

- Check SHP flow output is normal for the season.
- Check you have surplus water at the intake and it is submerged.
- Check your intake screen is clean.
- If you have a filter bag on the SHP suction line clean/exchange this regularly.
- Replace the oil after one month from new and top up the oil every 3 months as needed.

<u>Before every summer pumping season:</u>

- Walk the delivery line and check for any damage to the pipe.
- Check bearing health by noting if there is any play on the Smart Drive motor rotor.
- In NZ return to EcoInnovation if on the SHP service plan/agreement.
- Replace oil.
- Check for any water drips from the plunger seal weep holes. Drips indicate your SHP needs new seals to be fitted. This is easy to do yourself (refer to the service guide).
- Check for signs of water in the oil, milky colour. This can occur once the water side seals start to leak and/or the ceramic pistons are damage/worn. Squirts of high pressure water mist onto the oil side seals is the cause this of slow contamination. Change seals, pistons and oil.

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As-required maintenance
We also suggest you are wary of complacency. Since these systems work and give free pumped water, people often neglect to do any checks at all until the SHP 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 and ceramic plungers are available for an extra fee. Once you use them remember to re-order them.
If maintenance is not your thing, then join the SHP service plan and for a fixed annual fee, let us do the servicing for you (NZ only).

8.5. 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), BLDC and microprocessor on the shelf. This will mean that whatever the problem you can get your system going again quickly.

8.6. Lubricating the SHP

We recommend you to use SAE20W/30, SAE20W40 or SAE20W/50 or similar multigrade engine oil.

8.7. Changing the bearings

We will write a service manual for the SHP in due course.

8.8. Service agreement/plan NZ only (10 year life with annual premium)

Clients who join the service plan (this is set at $1/day - $365NZ + gst/year adjusted for CPI) at time of sale get the following extra benefits:

Annual service of the SHP when returned to EcoInnovation which includes:

- All new water side seals.
- Bearing check and replacement if needed.
- Pressure sensor check and replacement if needed.
- Check on big and small end camshaft bearing surfaces and replacement if needed.
- Check BLDC motor/stator parts and replacement if needed.
- Check BLDC electronic driver and replacement if needed.
- Upgrade BLDC driver software to latest release.
- Test for leaks.
- Premium warranty extension for a further 12 months.
- Return to you by courier.
- Eligible for one SHP swap if it fails in the next 12 months for no extra charge (you return the failed unit in the same box after a new or reconditioned unit arrives. This is despatched within 7 working days of receiving a valid claim and a legible picture of the SHP indentation plate (excludes any time the company is closed for holidays).

NZ clients who choose not to enter the service plan within 12 months of sale can service the SHP themselves or return the SHP to us for service on a time and parts “as required” basis. Parts and labour will be priced as listed on our web site. Services have a 3-months parts warranty only and should the SHP fail within 3 months the SHP will have to be inspected in our factory to ascertain the cause. If the cause is related to parts we supplied in the recent service it will be repaired for free, otherwise you will be charged for any other repair work required.

The service plan can be terminated by EcoInnovation by notice via email, this may eventuate if insufficient clients fail to join the service plan to make its continuation viable.

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9. Warranty and disclaimer

All SHP's have a 24-month warranty (which only covers non consumable parts) on condition they have been correctly installed and serviced.

Dealers on selling this product must facilitate warranty claims with the final client.
Trade on sellers in NZ who purchased from EcoInnovation may refer the client directly to EcoInnovation for service support.

EcoInnovation will only deal with the dealer for all sales made via a dealer.

Consumable parts on your SHP are not covered under warranty as these parts may need to be replaced from time to time and life of these parts is related to the cleanliness of your water resource and the run time hours.

9.1. What we require from the customer

Our warranty is valid provided the SHP has been correctly installed (within 12 months of sale), commissioned and maintained over the duration of its use with oil top ups as needed. EcoInnovation may request to see the logbook and pictures of the installation and failed components prior to processing any warranty claim. The claimant must respond promptly to any information request to ensure speedy processing of your claim. The claimant must complete the claim form that follows.

To avoid any doubt:

- Warranty starts from the date of sale as stated on the invoice from EcoInnovation to the buyer or dealer. Where dealers hold stock warranty starts within 12 months of purchased from us or at the time the dealer makes the sale (whichever comes first).
- The limited warranty does not apply to any product or part thereof damaged by:
  - a) alteration or disassembly
  - b) accident or abuse
  - c) corrosion
  - d) lightning
  - e) reverse polarity
  - f) flooding or submersion
  - g) repair or service provided by an unauthorized repair facility
  - h) operation or installation contrary to instructions pertaining to the product
  - i) failure to add or maintain the correct oil level

- EcoInnovation's liability for any defective product or any part thereof shall be limited to the repair, replacement, or refund of full amount paid for the SHP, at EcoInnovation's discretion. EcoInnovation does not warrant or guarantee the workmanship performed by any person or firm installing its products. Workmanship warranty applies when the SHP is serviced/repaired at our NZ factory. If you have your SHP serviced by a local provider check their terms of service, this work is not covered by our terms of service.

Warranty is conditional on the product being correctly installed and maintained as evidenced by your logbook, commissioning records and installation pictures.

9.2. How to make a claim

Bear in mind that claims are handled through the dealer that sold you your SHP. You must start by completing a claim form (next page).

If your claim is valid we will fix it by:

- Dispatching a replacement part to you promptly for clients outside NZ.
- Asking for the SHP to be returned to our factory for inspection and repair if in NZ or by sending out a replacement part if the client prefers and if this is appropriate for the problem.
- Sending out a new or reconditioned unit within 7 working days if the NZ customer is part on our annual service plan.

No travel cost to fit parts to your SHP are included under this warranty. The warranty is limited to:

- The supply of replacement parts for clients outside NZ.
- Receive, repair, replace & return the SHP for clients inside NZ.

9.3. Claim form

This must be completed and sent along with the pictures to the seller you bought the SHP from. Please send all of the information, incomplete applications will lead to delays while we seek the full picture.

What appears to be the problem?		TICK
A part has failed after running fine from some time	(details)	
Product does not work at all		
Product works but output is lower than expected		
Product output has decreased over time		
Bearings have failed but there is no other damage		
Bearings have failed and the motor has been damaged		
The SHP has a minor oil leak		
The SHP has a major oil leak		
Other please state ...		

Information we need from you	
Your name, Address, Email address	
Who installed and commissioned the SHP and on what date	
SHP serial number on nameplate	
From whom was the SHP purchased and what date?	
Delivery pipe length, and pipe ID installed	

Pictures we need from you include:

- Nameplate on the SHP
- Copy of any service records
- SHP installation pictures
- Water intake picture
- SHP system installation picture
- Close up photos of any damaged parts

We may request further pictures if necessary to fully understand the problem.

10. 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 SHP. Improper installation may result in damage to SHP, 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.

11. 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.

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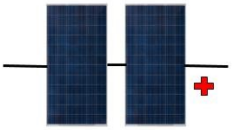
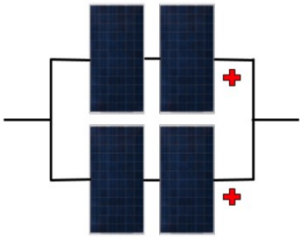
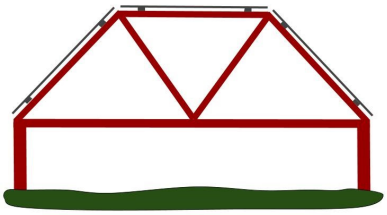
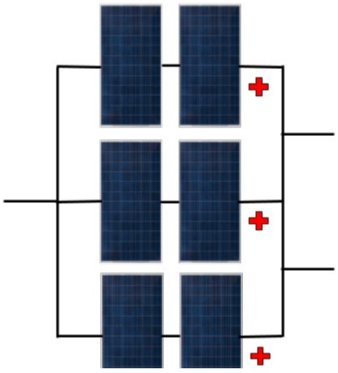
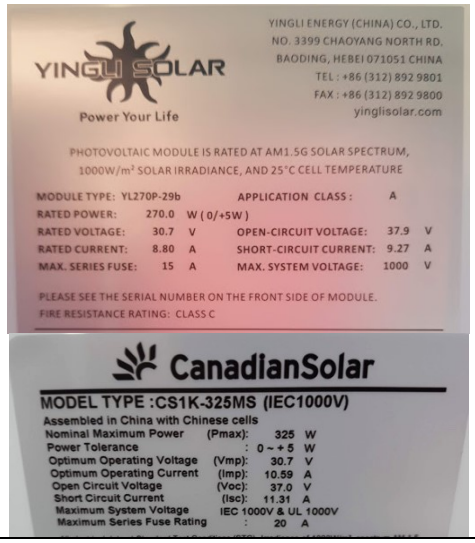
12. Product Specifications and Performance

12.1.1. SHP Electrical Input Specifications

Maximum input voltage	80 VDC (ripple free)
Minimum operational voltage	50 VDC (ripple free)
Target MPPV voltage for attached PV array	60-62 VDC
Minimum PV array size to operate (500W nominal) Always facing midday sun, or on shaded sites position midway in the shade-free zone.	500Wp. (In our examples that follow we have used 2 x 270W in series = 540W) 
Recommended PV array size (1000W nominal). Can be installed facing midday sun or on an East/West truss.	1000Wp (We have used 4 x 270W series pairs in parallel.) 
Maximum useful PV array size (1500W nominal) In areas of poor solar radiation two extra solar panels can be added to boost the pumped volume. This will benefit sites with head above 150m and sites that are often cloud covered, where more water is needed than four panels can provide. In such cases 2 panels should be mounted East, 2 facing Midday sun and 2 West. This is easy to do on a truss mounting frame. 	1620Wp (6 x 270W in 3 series pairs in parallel) **Note:** panel string fuses may be required see sections 3.2.3 and 3.2.4.  **Larger arrays (8 x 270W in 4 series pairs in parallel) can be employed for improved winter pumping provided that the DC switch is replaced with a 32 amp DC breaker and 15 amp string fuses are installed.**
Maximum voltage each PV panel (Voc must not exceed this at lowest temperatures expected at the installation site.)	40 VDC peak (+0V/-2.5V)
Nominal MPPV per panel	30 VDC (+2.0V/-0V)
Nominal PV panel size	270W +/- 10W
Max voltage drop in cable from PV to SHP	5% at 650W

Example panel to use: • Yingli YL260P-29B • Suntelite ZDNY-260P60 • CS1K-325MS • Or similar	

12.1.2. SHP Pump Specifications

Maximum dynamic head (including pipe loss)	300m or 30 bar
Rated static head	300m maximum (exclude pipe friction head.)
Maximum flow l/min per SHP	up to 15.79 l/min (depends on head)
Maximum unloaded rpm	1200 rpm
Typical operating rpm loaded range	150-1200 rpm
Maximum pressure stop setting	300m (30 Bar)
Minimum pressure stop setting	60m (6 Bar)
Input fitting size	25mm Hansen to suit 25mm suction hose. Fittings can be removed leaving a ½” BSP female thread to connect onto.
Output fitting size	20mm 16bar rated. Fittings can be removed, leaving a 3/8” BSP female thread to connect to.
Gross weight (packed in DHL carton)	<22kg
Net weight	<20kg
Boxed DHL carton dimension	44w x 35d x 33h cm
Service interval required for any warranty cover beyond first year	Every 12 months
Warranty	2-years on non consumable parts, provided the SHP has been installed and serviced correctly.
Oil required	Up to 0.5 litre SAE20W/30 or 20W/40 or 20W/50 (not supplied). Top up every 3 months (if required) and replace annually.

13. Installation details log

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

If you ever make a warranty claim we will ask to see pictures to prove it was installed correctly, you may want to do this now.

Installation details	Serial number _____
Date purchased	
Date installed	
Date for next service check	
Location of installation	
Delivery pipe inside diameter	mm or inch
Delivery pipe length	m or ft
Suction pipe inside diameter	mm or inch
Suction pipe length	m or ft
Static delivery pressure (SHP off)	kPa or PSI
Dynamic delivery pressure(SHP running)	kPa or PSI
Suction pipe lift or state “gravity feed”	m or ft
Performance data	
Flow rate of water to tank	l/s or gal/min
	l/day of gal/day
Supplier contact details	
Installer contact details	

We would also like you to let us know (via an email to your sales person) 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, average pumped flows will vary from site to site. Feel free to send us picture of your installation, we will contact you if we can see improvements that can be made to your installation☺.

DATE	NOTES

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