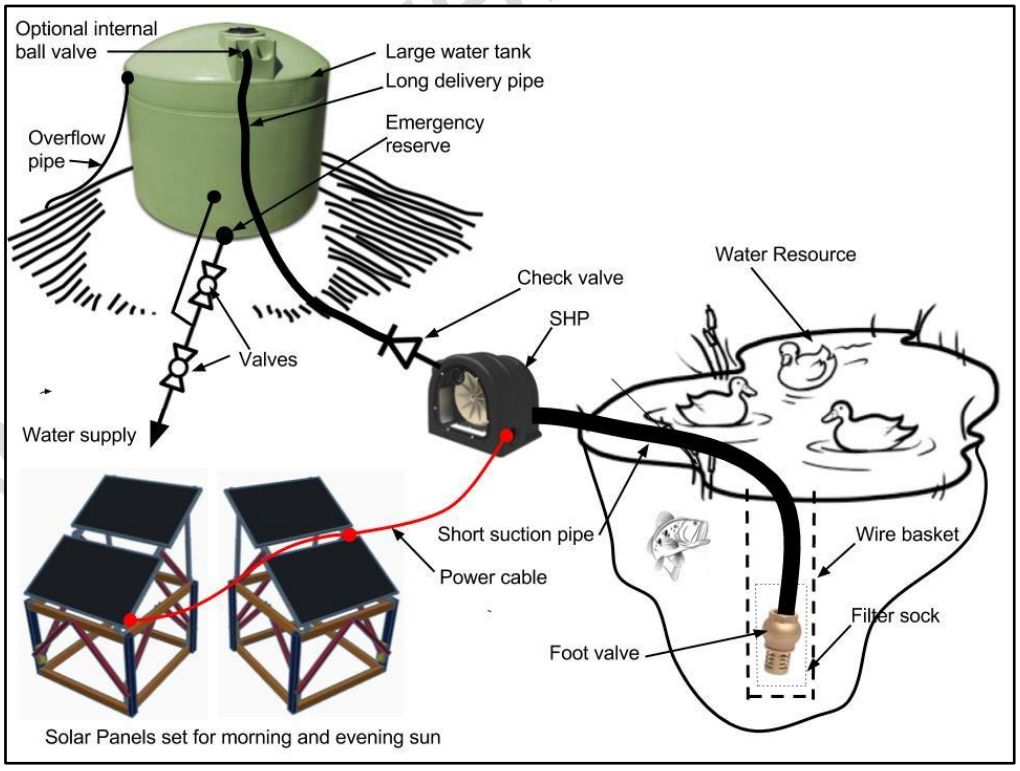
Advantages of a PowerSpout SHP

for solar-powered water supply to livestock in New Zealand

Typical installed PV array



General system layout

Everything you need on one pallet and a small carton

CONTENTS

1 Introduction

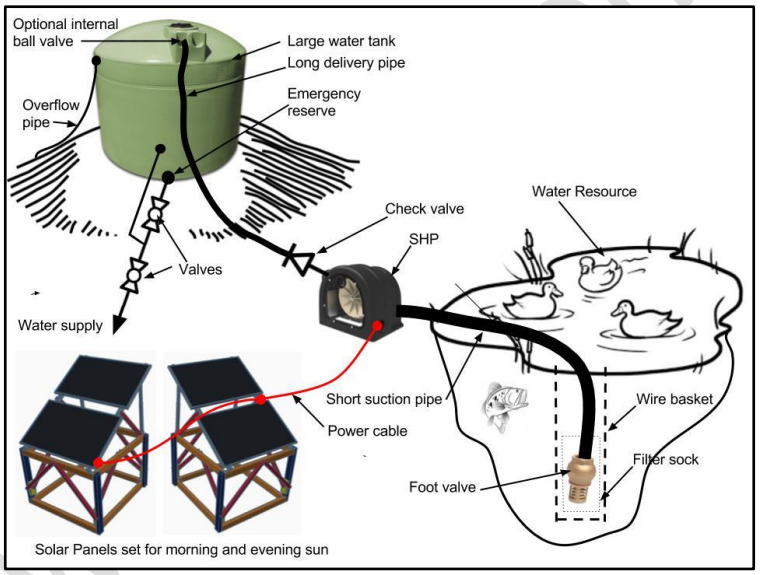
1.1 What is the PowerSpout SHP?

An ideal pump for filling livestock watering tanks, being clean, quiet, low maintenance and having low cost of ownership long term.

Made in NZ, it is easy and safe for a farmer to install without needing permits for water abstraction, PV erection or electrical installation. Annual servicing is easy to do yourself, or can also be provided by the NZ manufacturer for a fixed annual cost.

1.1.1 What's in the package?

The PowerSpout SHP-PV uses solar power directly from two PV arrays (supplied complete with racks) at "extra low voltage" (ELV). The brushless motor driving the pump is controlled by an internal circuit, without any need for batteries. The SHP can pump water up to a tank at heights of 10-250 metres above the intake.



Stock demand for water will tend to follow the solar cycle. More sun more water, less sun less water required.

The SHP is designed to be run from solar electricity, but it can alternatively be used with grid-power or an engine-driven generator if desired. (It can be purchased with or without solar panels - see section 3.)

1.2 Why provide reticulated water to livestock?

Replacing streams and dams with water tanks, pumps, pipes and troughs on hill country farms makes the flow of stock water more efficient. (See also section 6 for more detailed analysis.)

A recent report for the NZ government identifies the following advantages:

- Increased stock numbers.
- Increased lambing (12%) and/or calving percentages.
- Increased slaughter weights.
- Opportunistic stock finishing.
- Saved costs from not having to maintain dams on a regular basis.
- Economics paybacks from 1.5 years (3 year average over 11 farms)

Note that new NZ legislation will exclude dairy cattle from access to waterways from 2017 and further exclusions will follow in years to come.

1.3 When to choose the PowerSpout SHP for livestock water supplies?

Water pumping on farms is normally carried out by one of the following methods.

1.3.1 Gravity feed water systems

This option where possible is the best solution. But often it will be necessary to pump water.

1.3.2 Grid power

Daily grid connection charges to remote sites can often exceed the value of the power that the pump consumes. The Lines Company operating in the King Country is a good example of this and is a high fixed fee network operator. It may be more economic in some cases for sheep and beef farmers to change from grid power to solar power using the SHP-PV.

Where a grid connection is affordable, the SHP (motor and pump unit) can be powered from the grid (no PV panels required) via a mains AC/DC converter. This may be attractive compared to other pumps on high head sites.

Where a long wire is needed to reach the pump from the grid, the SHP can be powered via lower cost 80V DC ("ELV") cable.

1.3.3 Off-grid situations

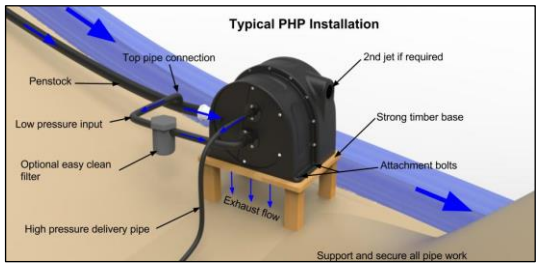
The SHP-PV is ideal for off-grid situations because it is self-powered and maintenance free for the season. The alternative is usually petrol or diesel engine powered unit.

Small engine-driven pumps are common in NZ and typically cost $1500-2500NZ complete. When used to fill large storage tanks on 100-200m lifts, they are often not very efficient, as the small pipes can only cope with 0.1-0.5l/s flow rates which can result in very low pumping efficiency and high fuel bills, not to mention the time required to fill the fuel tank each day.

The cost of ownership, fuel and labour to keep small fuel pumps operating can cost a typical sheep/beef farmer over $5000/year/pump. This means an SHP-PV can pay for itself in 1-year in some cases.

1.3.4 Our pumping turbine (where a sufficient head is available)

"Water rams" have been around for many years, and where you have naturally falling water can work really well.



We also manufacture a PHP turbine (Pelton Hydraulic Pump), which can be a better option on such sites.

For more information on our PHP refer to this document: PS PHP Advantages Document July 15

2 SHP (Smart Hydraulic Pump) Features:

2.1 Only one pump is needed for heads from 10-250m.

The lift (head) is altered by changing just one part, the cam. The cam sets the stroke of the pistons.

2.2 Positive displacement oil filled piston/diaphragm pump

The pump we use is a mass produced for high pressure spraying equipment. Such piston/diaphragm pumps are in the highest efficiency class. The pump is submersed oil lubricated, will run for many years and is easily serviced. Spare parts are plentiful and cost effective.

2.3 Direct Drive BLDC motor

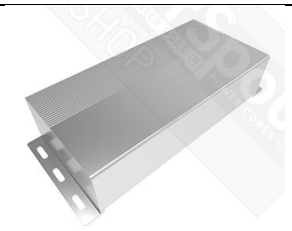
The motor we use is a slow speed direct drive brushless DC motor made by Fisher and Paykel that is copper wound and uses the latest high strength ferrite magnet technology that we specially modify for this pumping application. This motor is in the highest efficient class.

Fisher&Paykel

We have been running these motors as alternators in our hydro turbines for over 15 years. Spare parts are plentiful and cost effective.

2.4 Drive electronics

The power from the solar panels is converted and controlled by a mass produced BLDC electronic driver that runs between 50-80V DC. This 1.5 kW driver is a mass produced part for use on small electric vehicles. The BLDC is common and cost effective.

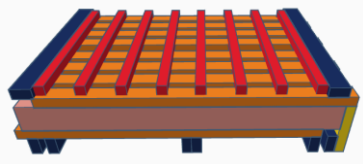


2.5 Install more pumps for larger farms that have greater water demands

Whether you require 5,000 litres per day or 100,000 litres per day, 1-10 SHP's can do the job required. This is called a parallel installation.

2.6 Everything needed is included and sent on a pallet

Other than your water tank and pipe everything you need is supplied and you can easily install it yourself or you can engage an approved installer if you prefer.



2.7 Need to lift to 320m heads or higher? Easy! Install an SHP for every 160m of head.

For more head, another SHP is installed after each lift. Installing them in a chain like this is called a "series installation". Remember that affordable plastic farm pipes are rated for up to 160m of head, so care is needed if pumping above 160m in a single lift. A 160m static head lift, combined with pipe friction, may result dynamic heads up to 200m. 250m head of pressure is the maximum dynamic rating of the SHP.

2.8 Purchase and maintain yourself or join the service/support plan for a fixed annual fee

Customers can choose to maintain their SHP themselves or return it every year under the service/support agreement.

The service/support plan will ensure that your SHP is in top working order provided the annual fee is paid and the SHP is returned every 12 months for service.

You have up to 12 months to decide if you want to join the SHP service agreement or not. If after 12 month of ownership you have not returned the SHP to our base for annual service and paid the annual fee then the service/support agreement terminates. Refer to our terms for more details.

3 SHP options

There are 4 options of the SHP available.

3.1 SHP-PV

The SHP-PV is the most common version and solar **P**hoto-**V**oltaic powered, available from June 2017. This option requires no grid, petrol/diesel engine or batteries. It only operates when there is sufficient sunlight on the solar panels. A large water tank is required to maintain the water supply for when the SHP-PV cannot operate.

3.2 SHP-PV & Gen

This version is the same as above but allows for a small 1kW petrol gen-set to be connected via a 230VAC to 80VDC compliant power supply supplied. This way if your SHP cannot meet your peak demand you can run the pump after sunset from a small gen-set to fill up the tank overnight. Once the fuel runs out and after sunrise the SHP will continue to run on solar power. This option will be available in 2018.

3.3 SHP-Grid

The SHP-Grid can be used to replace existing grid powered pumps. The pump can be set to turn off when a set pressure, tank float level or reservoir level is reached. This option will be available in 2018 and can be used with or without a header tank.

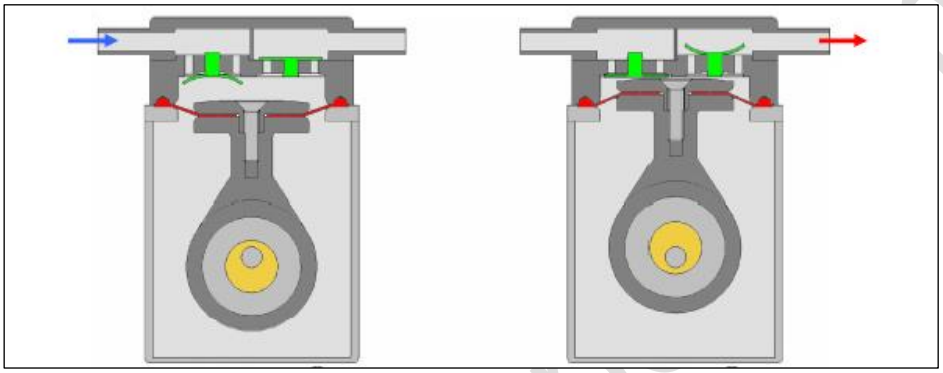
3.4 SHP-ELV

The SHP-ELV (**e**xtra **l**ow **v**oltage) exploits the cost advantage of different wiring rules for extra low voltage cables (<120VDC in NZ). When grid power is close by, typically within 250-1000m from where the pump is located. A low cost, low voltage and low power cable is run from the grid location to the SHP-ELV. At the grid location a 230VAC to 80VDC compliant power supply is plugged into a 10-amp 230V AC socket and the 80 VDC side is connected to the long ELV cable that connects to the

SHP-ELV. This avoids the high cost of extending the 230 VAC network and ongoing connection fees. This option will be available in 2018.

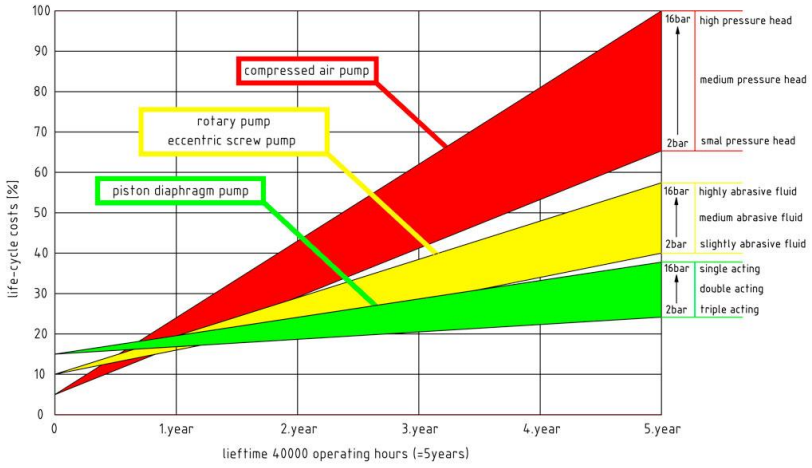
4 Piston pumps versus high speed borehole pumps

The PowerSpout **S**mart **H**ydraulic **P**ump (SHP) uses a dual piston/diaphragm pump. These simple oil lubricated pumps are in the highest efficiency class (80-90%).
Compared to other solar pumps (centrifugal and helical screw) that run at 1000-6000rpm, the SHP runs at 1/10 of this speed, around 100-600 rpm, greatly prolonging the life of parts.



The above image shows operation of one piston, suction draws in water from your resource (blue) then displaces high pressure water (red). We select a cam with a suitable stroke for the head at your site and the size of solar PV array installed.

4.1 Life cycle costs



Piston diaphragm pumps have the lowest life cycle costs, as consumable parts that need replacement are low cost and easy to replace. The SHP is also easy to service.

4.2 Why are most other pumps submersible bore type

Globally, most waters resources are sub-surface. Bore pumps can be used on bores, wells, streams, lakes and dams. Because bores are of a small diameter such pumps typically employ centrifugal or

helical rotor types, this compact size requirement means they have to be high speed for direct drive. High speed is not good for long life expectancy.

In NZ and many other farming countries, most pumped water is from springs, streams, rivers, lakes and small farm dams. This is because bores are costly to drill and taking water this way (for farm stock drinking needs) is normally not permitted and requires consent. Also bore water can contain unwanted minerals. For an NZ government document on bores read here.

4.3 Bore hole abstraction permit/consent

Permission is generally required both to drill a bore and to use the water. Both consents are granted by regional councils in NZ. Taking too much groundwater can affect other bore water supplies in the area, reduce water levels at the surface and even cause salt water to be drawn into an aquifer from the ocean. For the same reasons, permission is needed to increase the amount taken beyond what has been consented. In some areas there is a lower limit below which water abstraction is a 'permitted activity' and no consent is needed. This depends on the local circumstances. The local regional council can advise on their specific requirements. Be ready to tell them how much water is required and the location it will be drawn from.

4.4 Taking surface water permit/consent

In general taking water from a river, stream, lake or aquifer *for use in production, processing, irrigation* requires consent. This can be a costly and time consuming undertaking.

But almost all councils in NZ make the taking water for *domestic and stock supplies* a **permitted activity**. As such pumps like the SHP can be installed without any permit required. There may be a few exceptions for waterways of endangered species, so always check first.

5 Water Pumping Solutions – The Competition

In NZ these are some of the main options.

5.1.1 The Lorentz range of pumps

Lorentz manufacture a large range of quality pumps (designed in Germany and made in China) imported and distributed into NZ, click here for a link of suppliers.

5.1.2 The ePump

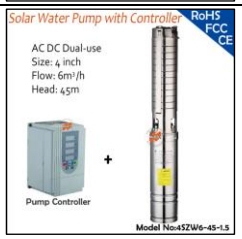
The ePump manufactured in NZ by Isaac's Pumping and Electrical from domestic and imported parts.

5.1.3 The SHP-PV

The PowerSpout SHP-PV is made in NZ by EcoInnovation from domestic and imported parts.

5.1.4 End client imported Chinese pumps

On international web sites there are a large number of solar centrifugal PV pumps available, mainly for heads in the range 10-60m. Above 60m lift your options are more limited. Most of these pumps are low cost disposable units with delivered prices from $150 US upwards (pump & controller only).



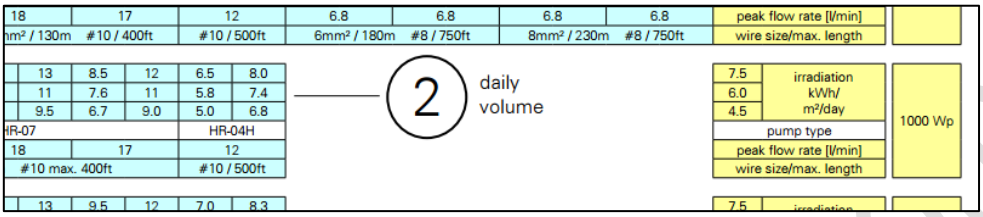
5.1.5 Pumpstore.co.nz

The www.pumpstore.co.nz sell a range of solar pumps of Chinese origin from $880 to $2145 NZ.

5.2 Examples @ 120m lift for each pump option

Please note this may not illustrate the peak efficiency, but is a practical example for a simple comparison that can be easily made.

5.2.1 Lorentz PS1200 HR-07 – helical rotor pump



Details on the theory of this pump type click here

With 1000W of PV, 120m head and 17l/min peak flow.

Pumping power = head (m) x Flow rate L/hr x 9.81 (m/s^2) / 3600
= 120 x (17 x 60) x 9.81 / 3600 = 333.5W
PV power peak utilisation efficiency = 333.5/1000 = 33.3% (helical rotor pumps have a higher efficiency than centrifugal pumps).

5.2.2 The SHP-PV

Fitted with 1040W of PV

Pumping power = head (m) x Flow rate L/hr x 9.81 (m/s^2) / 3600
= 120 x (18 x 60) x 9.81 / 3600 = 353W
PV power peak utilisation efficiency = 353/1040 = 33.9%

View calibration test here 120m head and 18 l/min

5.2.3 The ePump

The ePump difference

- Built to withstand the harshest environments
- Three models
  - 60 metre pumping 23 ltrs per minute
  - 120 metre pumping 15 ltrs per minute
  - 40 metres pumping 30 ltrs per minute
- Eliminates regular checks for maintenance and refuelling
- Environmentally responsible alternative
- Labour efficient
- No ongoing power or fuel costs

Pumping power = head (m) x Flow rate L/hr x 9.81 (m/s^2) / 3600
= 120 x (15 x 60) x 9.81 / 3600 = 298.3W.
1800W of PV is supplied with the pump
PV power peak utilisation efficiency = 1800/289.3 = 16.35%

5.2.4 The pump store

Technical Specifications:

Motor power rated: 750W
Voltage: 48V
Solar Panel Requirement: min 1125W
Head: 105m
Max Flow (L/Hr): 1800
Clear, free from solid or abrasive substances,
Outlet: 25mm,
Rating: Continuous
Overall Dimension (cm): 10 X 10 X 49

SOLAR PUMP PERFORMANCE DATA

Power	Voltage	Match solar panel reference		Flow & Lift				
W	V/DC	Power	VMP/Panel	Max. flow	Max. head	m/hr & m		
200	36	200*1.5	17.5V/PC	1.1m/hr	64m	0.3m/hr 45m	0.4m/hr 40m	0.5m/hr 37m
550	72	550*1.5	29.5V/PC	1.5m/hr	95m	0.5m/hr 77m	0.74m/hr 63m	0.8m/hr 52m
750	48	750*1.5	29.5V/PC	1.8m/hr	105m	0.72m/hr 94m	0.84m/hr 86m	0.96m/hr 79m
2200	280	2200*1.5	29.5V/PC	7m/hr	150m	3.6m/hr 100m	4.2m/hr 90m	4.8m/hr 79m

750W version with 1125W of PV
Pumping power = head (m) x Flow rate L/hr x 9.81 (m/s^2) / 3600
= 94 x 720 x 9.81 / 3600 = 184.4W.
PV power peak utilisation efficiency = 1120/184.4 = 16.5% (note this is at 94m and not 120m as per the other 3 examples)

5.3 Published Peak Efficiency

- SHP-PV (piston diaphragm oil lubricated) 57%
- Lorentz (centrifugal) 48%
- Lorentz HR helical rotor (depends on model) 60-64%
- Pump Store (not published) 25-35% estimated
- ePump (not published) 25-35% estimated

The Lorentz HR has the highest peak efficiency but a lower peak flow than the SHP-PV. This implies that peak flow and peak efficiency do not occur together and that the SHP-PV has a flatter efficiency curve (which is typical for positive displacement pumps). It is clear that the SHP-PV and the Lorentz PS1200 HR-07 have very similar performance at the 120m comparison we have made. The performance of all other pumps listed is much lower.

5.4 Pump comparisons based on an estimate of likely installed costs to give a $/W peak flow comparison

Name	Type	Pump or system cost $NZ	PV Size Watts	PV cost $NZ	Frame cost $NZ	Balance of system $NZ	Concrete foundation costs $NZ	Labour costs $NZ	Total Cost	Peak flow 120m @ l/min	$ spent per l/min at 120m
SHP-PV	Piston/diaphragm	4999	1040	inc.	inc	inc	n/a	624	5623	18.0	312
*Lorentz PS1200 HR-07	Helical rotor	4500	1000	1200	300	396	333	600	7329	17.0	431
Pumpstore	Centrifugal	1080	1125	1350	337.5	445.5	375	675	4263	9.4	453
ePump	Piston	12695	1800	inc.	inc	inc	599	1080	14374	15.0	958

- PV has been priced at $1.2NZ/W for tier 1 panels.
- PV Framing cost has been estimated at 25% of PV cost if not supplied.
- Balance of system costs have been estimated at 33% of PV cost if not supplied.
    - Breaker(s), wire, connectors, conduit, cable clip, power meter, flow meter, enclosures, signage etc.
- Concrete foundation & labour costs are estimated at 33% of PV array size if required.
- Labour costs are based on 1 person 8-hour day per 1000W of PV at $75NZ/hour.
- *Cost of Lorentz pump has been estimated here as they do not widely advertise costs.

The above table is indicative of likely costs. Readers should do their own research to validate the numbers used.

The PowerSpout SHP-PV is the only option that is delivered as a complete kit, which can be installed by the farmer.

6 Advised reading for hill country farmers on the topic of water reticulation

Information that follows (unless stated otherwise) has been extracted from these main documents:

- Economic Evaluation of Stock Water Reticulation on Hill Country
- Clean Water - NZ Government Policy Document 2017
- NZ Farm Facts Compendium 2016

6.1 Water Reticulation Study: Benefits of Stock Water Reticulation

This study prepared for the Ministry for Primary Industries and Beef + Lamb New Zealand lists these benefits from replacing streams and dams with **water tanks, pumps, pipes and troughs** on hill country farms:

- Improved farm performance following the installation of water reticulation was due to:
    - Increased sub-divisional fencing.
    - Better grazing management.
    - Improved pasture utilisation.
    - Better pasture production.
    - Improved stock numbers and performance.

Farmers interviewed also stated the following:

- Dam water supplies are often low quality, can dry up and often require stock to be rescued. This issue was eliminated.
- Farmers noted the "peace of mind" that the water scheme gave them (and their staff).
- Most farmers had environmental plans, and noted that the stock water reticulation and subdivision made implementing the plan easier, especially with fencing off waterways.
- Good stock water reticulation lessened the impacts of drought.

6.2 The NZ Law

The Animal Welfare Act (1999 NZ) requires managers of livestock to provide "proper and sufficient food and water". This is why the abstraction of water for stock drinking is a permitted activity if from surface water.

6.3 NZ Government Policy on Waterways

Stock exclusion from Waterways (2017 onwards):

<table>
<tr><th>Farm/stock type</th><th>Plains (0-3˚)</th><th>Undulating / rolling land (>3-15˚)</th><th>Steeper land (>15˚ and over)</th></tr>
<tr><td>Dairy cattle (on milking platforms) and pigs</td><td colspan="3">1 July 2017 for waterways over 1 metre wide on all slopes
1 July 2020 for waterways less than 1 metre wide on the plains</td></tr>
<tr><td>Dairy support (on either land owned/leased by the dairy farmer or third party land)</td><td colspan="2">1 July 2022 for all waterways on the plains regardless of size and waterways over 1 metre wide on rolling land</td><td>Only where break feeding, by 1 July 2022</td></tr>
<tr><td rowspan="2">Beef cattle and deer</td><td>1 July 2025 for all waterways regardless of size</td><td>1 July 2030 for waterways over 1 metre wide</td><td></td></tr>
<tr><td colspan="3">Where break feeding, by 1 July 2022</td></tr>
</table>

If only sheep farming there are no proposed requirements for stock exclusion from waterways. Fines for non-compliance are $2000 for each event (then a reasonable time will be allowed to remedy). Hence, it is likely that sheep and beef farmers will not fence any waterways but that paddocks adjacent to waterways will only be used for sheep (cattle excluded). This may still require some fencing on the farm to be done. Cattle only farms will have to fence all water ways > 1m wide on land of < 15 degree slope by 2030 at the latest.

6.4 Typical stocking rates in the Water Reticulation Study

- Steep hill country or low fertility soils typically have 6 to 10 stock units per hectare.
- Easier hill country or higher fertility soils typically 7 and 13 stock units per hectare.
- Most hill country farms have between 5,000 and 35,000 stock units.
- The average farm in the stock water reticulation study had 10,000 stock units and 100 paddocks.

- Average stocking rate was 9 stock units per hectare
- Average farm was 40% cattle and 60% sheep
- Average lambing rate 136%

The farms used in the water reticulation study are about twice the size of the average sheep and beef farm in NZ.

6.5 Typical national stocking rates

Farms by farm type 2012

	NUMBER OF FARMS[1]	AGRICULTURAL AREA (000 HA)
Dairying	12,150	2,415
Sheep & Beef Farming	25,113	9,328
Cropping	3,297	284
Deer Farming	1,128	287
Pig Farming	225	11
Poultry	135	3
Total	42,048	12,327
Other (including forestry)	16,020	2,067
TOTAL ALL FARM TYPES	**58,068**	**14,394**

1 Includes non-commercial smallholding farms.
Source: Statistics New Zealand, 2012 Agricultural Census

25113 sheep and beef farms.

Average size 371 ha from above, Land Information NZ for 2012 has the average sheep and beef farm listed at 678 ha (if smaller beef only farms are accounted separately).

If we assume the average stocking rate for hill country farms is 8 SU/ha then the average farm has 5424 SU. If sheep are 1 SU at 60% and beef cattle 5 SU at 40% then the average sheep and beef farm has about:

- 3254 Sheep
- 434 Beef cattle

7 Typical water requirements

Table 1: Estimates of water requirements for livestock (ANZECC 2000)

Type of Livestock		Average daily consumption (litres/head)	Peak daily consumption (litres/head)
Sheep			
	Lactating ewes on dry feed	9	11.5
	Mature sheep on dry pasture	7	8.5
	Mature sheep on green pasture	3.5	4.5
	Fattening lambs on dry pasture	2.2	3
	Fattening lambs on green pasture	1.1	
Dairy Cattle			
	Dairy cows in milk	70	85
	Dairy cows, dry	45	60
	Calves	22-25	30
Beef Cattle*			
	Breeding Cow	30	45
	Yearlings	20	30
	Calves	10	20
Deer*			
	Mature Hind	5.7	11
	Hind 15-27 months	5.4	11
	Mature stag	6.6	13
	Stag 15-27 months	6.3	13
	Yearling	10	15
Horses			
	Working	55	70
	Grazing	35	45

Assuming:

- average beef cattle consume 20 l/head
- average sheep consume 5 l/head

Note – the ratio of beef to sheep make little difference to the calculated water requirements.

The average NZ sheep and beef farm will require:

- 3254 Sheep x 5 l/head = 16270
- 434 Beef x 20 l/head = 8680
- Total = 24950 l/day

A standard roto-moulded plastic water tank holds 25,000 litres. An average farm will need 1 tank per day if all animal water is delivered to troughs via a single tank. On farms of this size just 1 tank is unlikely. The reality is that stock require little supplementary water on wet days and the requirement of 1 tank per day is likely to be the average summer requirement. Demand will tend to follow the solar cycle, more sun more water, less sun less water required.

As such a solar powered pump is a very good option. If we assume for this example:

- Hilltops on a farm are at 180m above valley bottom.
- 50% of the water needs on the lower rolling part of the farm (up to 60m) are met with a grid powered water pump.
- Higher hilly parts of the farm are met with solar pumps and tanks at two high locations.

Then each location needs about 6000 l/day and with a 25,000 litre tank would have 4 days of storage. This storage is required to meet the needs of peak demands, severe drought cover and for maintenance down time.

In this case two of our SHP pumps (60m above the valley floor) with tanks (120m above the water resource) would meet the needs of the farm. If the farm hills were only 80m high, then two units on

hills would come close to meeting all the needs of the farm without the need for a grid-powered pump. If the solar pumps fall a little short in times of drought then the PV array can be easily increased from 1kW to 1.5kW to ensure that on those sunny and dry overcast days the pump is delivering the most that it can.

Should even more water be needed then another SHP can be added in parallel to double the amount that can be pumped.

For backup and to supplement in times or severe drought (high demand) a small petrol pump or generator (SHP PV & Gen option) kept in storage for backup is good advice.

7.1 Typical capital cost for a solar water reticulation scheme:

- Solar Pump(s) and PV array(s).
- Storage tanks.
- Pipe.
- Troughs and fittings.
- Earthworks (tanks levelling and burying of pipes).
- Contract labour.
- Fencing (e.g. around water storage tanks, PV panels and pumps).
- New paddock fencing as required.

7.2 Typical operating costs

- Repair and maintenance to solar pump (refer to our service plan).
- Insurance cover if required.

8 Summary

A PowerSpout SHP is a very versatile product with these main advantages:

- Arrives in a complete kit.
- Is very efficient for higher head lifts (typically used in the 60-200+m lift range).
- Is more cost effective than any other product on the NZ market installed.
- Made in NZ.
- Can be installed by the farmer.
- Can be serviced in NZ as required by the manufacturer or the farmer.
- Is electrically safe (when correctly installed) as it runs at ELV (60 VDC) and hence does not need a COC and is very unlikely to be an electric shock hazard.
- No permit for stock water abstraction is required for surface water takes.
- No building permit for the PV array structure is required.
- No system earth is needed (SHP – PV)
- Owner can join the service/support plan for a fixed annual fee.