SLUDGING

Manual drilling series

TECHNICAL TRAINING HANDBOOK ON AFFORDABLE MANUAL WELL DRILLING

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TECHNICAL TRAINING HANDBOOK ON AFFORDABLE MANUAL WELL DRILLING

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PRACTICA Foundation develops and disseminates low-cost appropriate technology in water and renewable energy in developing countries. We focus on technology that responds to local cultural contexts, can be locally produced and maintained, and supports existing markets.

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Disclaimer

This instruction manual is available in English and in French and has been developed for use in **technical training courses** organised for the intended users. In case you want to organize such training, you may contact the PRACTICA Foundation for further information and support.

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Foreword

The high cost of developing potable water sources prevents many rural people from gaining access to clean, safe water supplies. Increasing access to improved water supply for under-served people and communities while keeping up with growing populations will require serious consideration of lower cost alternatives to the existing expensive water supply options. The manual drilling sector has proven itself as a successful, lower-cost approach with great potential under suitable conditions. In numerous countries manual drilling techniques are used as an alternative or to complement machine drilling. Drilling 'shallow' water wells by hand using local enterprises, can reduce the cost of a well by a factor 4 - 10 compared to a machine-drilled borehole. This cost reduction not only enables NGOs and Governments to construct more water points, but also 'opens the door' to villagers, farmers, schools and small communities to finance well construction independently through the private sector. Strategies and programs should be adopted to professionalize the manual drilling sector in order to scale-up rural water supply for drinking and irrigation purposes.

Variations of four manual drilling technologies are being used, each with their own advantages, disadvantages and suitability for different geological conditions. This handbook describes the practical aspects of the drilling technique Sludging and is part of a series of 5 handbooks providing the basis for local entrepreneurs to start practicing affordable well drilling.

We suggest that this drilling handbook is used in combination with the manual: **'Understanding Groundwater & Wells in manual drilling'.**

READERSHIP

This handbook can be used as a guide during training sessions for well drillers, local trainers and quality controllers. It also serves as a reference for drilling supervisors, NGOs, development agencies, manual drilling teams and enterprises during the entire drilling process. The handbook consists of three sections that can be read together, or used and printed separately for the various target groups.

NOTE

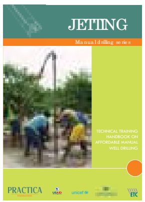
Technical terms and the way in which subjects are explained are based on the average expected educational level of the intended users. Sometimes, the use of complicated geological and technical terms has been avoided to create better understanding. Please keep in mind that the objective of the handbook is to create better understanding of well drilling in practice, aimed at technical workers of manual drilling teams who may have a limited educational background.

Colophon

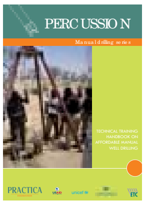
AVAILABLE MANUALS IN THIS SERIES:

Technical training handbooks on affordable manual well drilling.

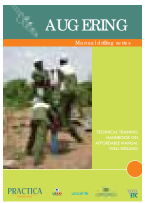
These practical handbooks create awareness of manual drilling for affordable water supply and a roadmap for implementation of manual drilling programs. The manuals provide an extensive and detailed guide for trainers and drilling teams in the use of various drilling techniques for making affordable boreholes. The techniques are explained in simple and understandable language, using clear illustrations and drawings.



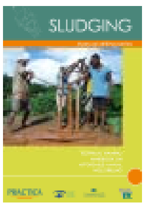
1. **Manual drilling series: JETTING**
   This handbook describes in detail the various jetting techniques that can be used to drill wells in loose and soft soil formations. With this technique, wells are drilled in a number of hours rather than days.



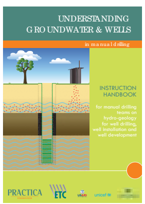
2. **Manual drilling series: PERCUSSION**
   This handbook describes in detail the percussion technique. Although the technique is slower than other drilling techniques, it is the only manual drilling technique that is able to drill through consolidated rock layers.



3. **Manual drilling series: HAND AUGER**
   This handbook describes the hand auger technique. This cheap and effective technique is very suitable for sinking shallow wells in soft soils and is excellent for soil surveys. Many drilling teams have this technique in their toolkit to complement other drilling techniques.



4. **Manual drilling series: SLUDGING**
   This handbook describes the sludging technique, and in greater detail the ROTA-sludge technique. It is a combination of sludging and percussion and is particularly useful due to its versatile application for a range of soil formations.



5. **Manual: 'Understanding Groundwater and Wells in manual drilling'**
   The manual 'Understanding Groundwater & Wells in manual drilling' complements the 4 technical training handbooks and highlights those essential subjects which are relevant to manual drilling, geo-hydrology, hygiene, well installation and well development in practice, in simple and understandable language.

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Module 1

THE CONTEXT OF MANUAL DRILLING

This module creates awareness on manual drilling and provides a road-map for implementation. It is meant for NGO's, governments and implementing organisations and those interested in using manual drilling for affordable water supply.

Module 2

USING THE SLUDGING TECHNIQUE

Module 2 describes the drilling technique in detail and includes: how the technique works and where it is can be used. This module is a step-by-step explanation that makes use of cartoons to illustrate the drilling process. This module is designed to be used by technical trainers and as a reference for manual drilling teams.

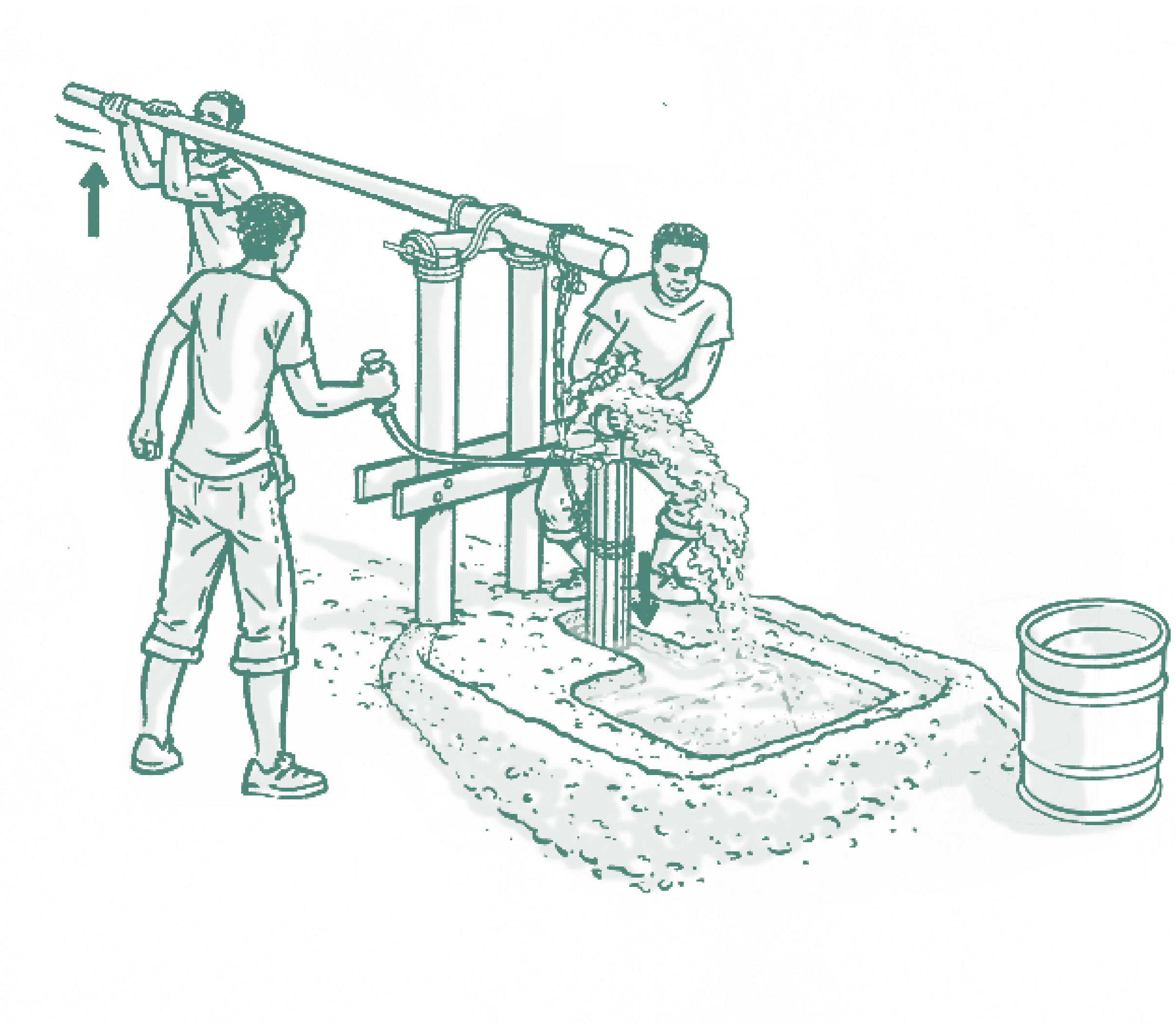
Module 3

MAKING THE DRILLING EQUIPMENT

Module 3 is meant for local workshops that want to fabricate drilling equipment. It consists of a package of technical drawings, tips for construction and a list of materials that are necessary to make a complete set of drilling equipment.

SLUDGING

Module 1



THE CONTEXT OF MANUAL DRILLING

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1. WHAT IS MANUAL DRILLING

Affordable water

Manually drilled wells for water supply are more affordable than machine drilled wells and more productive than hand dug wells, thereby providing access to improved sustainable water points at a lower cost. This module describes the context in which manual drilling is used in various countries and elaborates on the techniques and its implementation. It gives insights and creates awareness and is meant for NGO's, governments, implementing organisations and those interested in using manual drilling for affordable water supply. This module might also be interesting for the manual drilling teams themselves, especially once they have gained more field experience in well drilling.

Manual drilling is a practical and affordable solution for wells less than 40 meters deep in alluvial soils (loose material, such as clay and sand) and soft weathered rock formations (such as soft sand stone and lime stone). There are many areas around the world where it can effectively provide water for drinking and for irrigation to un-served rural populations at a fraction of the cost of conventional drilling. This is especially true in small isolated communities that will never benefit from the large donor funded drilling programs because they are often not included in national plans.

WHY MANUAL DRILLING?

- Cost savings: 4-10 times cheaper than a machine drilled well of the same depth.
- Better access to drilling sites with lightweight equipment, remote communities can now be reached.
- Locally manufactured drilling equipment, under € 2,000 initial investment for start-ups.
- Ready-to-go in emergency situations and in politically unstable countries.
- It creates jobs and knowledge remains in the country, even after donor projects are finished.
- Overcomes problems in water quality and quantity in comparison with hand-dug wells.
- Can be used for both drinking water and irrigation.

Machine drilled wells are high in quality, but also very expensive. Hand dug wells are lower in cost and very useful in formations with a low permeability due to their capacity to store water which seeps in through well walls overnight. However, the total yield/day may be low, and water quality may be poor because the water comes from an open source allowing pollutants to enter easily. Hand dug wells also often collapse if not properly lined. A hand dug well lined with concrete rings, preventing it from collapsing, has a high yield, but the price will come close to that of a machine drilled well.

The cost of wells vary among countries and will generally be in the range of € 5000 – 15000 for a 30-meter deep machine drilled well and € 2500 - € 8000 for a lined hand dug well. In many countries manual drilling techniques are used as an alternative.

Costs of 30 meter deep manually drilled wells vary from about € 100 - 2500, depending on geology, country and application (i.e. small scale irrigation to high quality community wells for potable water). The equipment for manual drilling can be locally manufactured, transported and maintained.

2. CHOICES: THE 4 MANUAL DRILLING TECHNIQUES

When a borehole is drilled, different types of geological formations (soil layers) can be encountered. To drill through these diverse formations a range of different manual drilling techniques have been developed and are used around the world. In each case the drilling technique must (a) break or cut the formation, (b) remove the cut material (the soil) from the hole, and (c) if necessary provide support to the walls of the hole, to prevent collapse during drilling.

Each drilling technique has been developed for either one or a range of specific formations (soil layers) ; therefore it may be possible that combinations of different drilling techniques are used to drill a single borehole. All existing drilling techniques can be divided into four main drilling principles: Hand Auger, Manual Percussion, Sludging and Jetting. Within these four main drilling principles, a wide range of variations have been developed in various countries.

THE HAND AUGER consists of extendable steel rods, rotated by a handle. A number of different steel augers (drill bits) can be attached at the end of the drill rods. The augers are rotated into the ground until they are filled, then lifted out of the borehole to be emptied. Specialized augers can be used for different formations (soil types).

Above the water table, the borehole generally stays open without the need for support. Below the water table a temporary casing may be used to prevent borehole collapsing. Drilling continues inside the temporary casing using a bailer until the desired depth is reached. The permanent well casing is then installed and the temporary casing must be removed. Augers can be used up to a depth of about 15-25 meters, depending on the geology.

Geological application; suitable for unconsolidated formations: Sand, silt & soft clay.

MANUAL PERCUSSION uses a heavy cutting or hammering bit attached to a rope or cable and is lowered in the open bore hole or inside a temporary casing. Usually a tripod is used to support the tools. By moving the rope or cable up and down, the cutting or hammering bit loosens the soil or consolidated rock in the borehole, which is then extracted by using a bailer. Just as with hand augering, a temporary casing of steel or plastic may be used to prevent the hole from collapsing. When the permanent well screen and casing are installed, this temporary casing has to be removed. Manual percussion drilling is generally used up to depths of 25 meters.

Geological application; suitable for unconsolidated and consolidated formations: Sand, silt, stiff clays, sandstone, laterite, gravel layers and small stones

SLUDGING uses water circulation to bring the cuttings up to the surface. The drill pipes are moved up and down. On the down stroke, the impact of the drill bit loosens the soil and on the up stroke, the top of the pipe is closed by hand (or valve), drawing up the water through the pipe and transporting the cuttings to the surface. On the next down stroke, the hand (valve) opens the top of the pipe and the water squirts into a pit, in front of the well. In this pit, the cuttings separate from the water and settle out, while the water overflows from the pit back into the well. The borehole stays open by water pressure. Thickeners (additives) can be added to the water in order to prevent hole collapse and reduce loss of working water (drill fluid). Sludging (with or without rotation) can be used up to depths of about 35 meters.

Geological application; suitable for unconsolidated formations: Sand, silt and clay. If rotated (including a drill bit) it may be possible to penetrate softer-consolidated formations such as stiff clays, soft sandstone, and weathered laterite.

JETTING is based on water circulation and water pressure. As opposed to sludging, water is pumped down the drilling pipes. The large volume of water has an erosive effect at the bottom and the 'slurry' (water and cuttings) are transported up between the drill pipe and the borehole wall. A motor pump is used to achieve an adequate water flow. The drill pipe may simply have an open end, or a drill bit can be added and partial or full rotation of the drill pipe can be used.

Thickeners (additives) can be added to the water in order to prevent hole collapse and reduce loss of working water (drill fluid). Jetting (with rotation) is generally used up to depths of 35-45 meters.

Geological application; suitable for drilling in alluvial material such as weakly cohesive sands, silts and thin layers of soft clay .

CHOICES FOR MANUAL DRILLING TECHNIQUES

Drilling Technique*	Equipment cost (€)	Average drilling speed for 15m in different geological formations (days)**				
		Weak cohesive sand, silt gravel	Soft clay <u>Stiff clay</u> formations	Soft consolidated formations	Soft weathered rock	Un-weathered Crystalline basement rock, e.g. granite
Hand auger	200 - 600	1	1-2 <u>2-4</u>	Not suitable	Not suitable	Not suitable
Percussion	300 -1200	2-3	2-3 <u>3-4</u>	> 3	> 8	Not suitable
Rotary Jetting	800 - 1400	1	1-2 <u>Less effective</u>	Not suitable	Not suitable	Not suitable
Rota Sludging	600 - 1000	1-2	1-2 <u>2-3</u>	> 3	Less effective	Not suitable

Drilling Technique*	Advantages	Disadvantages	Average drilling depth (m)
Hand auger	Easy to use above groundwater table. Cheap equipment	Use of the temporary casing if clay layers are penetrated is very limited If a collapsing sand layer is encountered below a clay layer (through which the temporary casing could not penetrate), the borehole does not stay open	15 - 25
Percussion	Drills hard formations	Slow and high equipment costs	25
Rotary Jetting	Quick	Lots of working water is needed at once	35 - 45
Rota Sludging	Easy to use Applicable in most soft formations	Highly permeable layers (coarse gravel) causes loss of working water and cannot be drilled	35

* Note: Drilling teams are keen on using a variety of drilling techniques to penetrate different geological formations.

**Note: Many different soil layers may be encountered during the construction of one borehole. The information given in the table is an indication of the drilling speed in one particular type of soil.

3. WHAT ORGANIZATIONS MUST KNOW

HOW TO IMPLEMENT MANUAL DRILLING

Using manual drilling as implementing tool for affordable water supply is possible for a wide range of qualities and scales. Before one can start the implementation of a manual drilling program there is a whole list of things to be considered. For example:

- What is the required quality of the wells?
- Who will pay for the construction of the water point?
- Who will be the end user of the well (households, community, farmers, refugees in camps, etc)?
- Are we drilling for potable water, irrigation water or multiple use?
- What is the number of wells that need to be drilled per year?
- Is there already an existing manual drilling sector present and what is their capacity?
- What is the need and scale for quality monitoring?
- What is the size of the project area?
- What is the hydro-geologic potential for manual drilling in the project area (type of soil and the depth of groundwater)?
- What is a sustainable number of drilling teams needed (based on the demand)?
- What is the relation between user density and hydro-geology in the project areas (how many people can we reach with manual drilling)?
- What are the objectives of the implementing organization?
- Etc.

The answers to all these questions (and the objectives for scale and costs) provide the basis for making the right choice of the approach for training and implementation. A few examples:

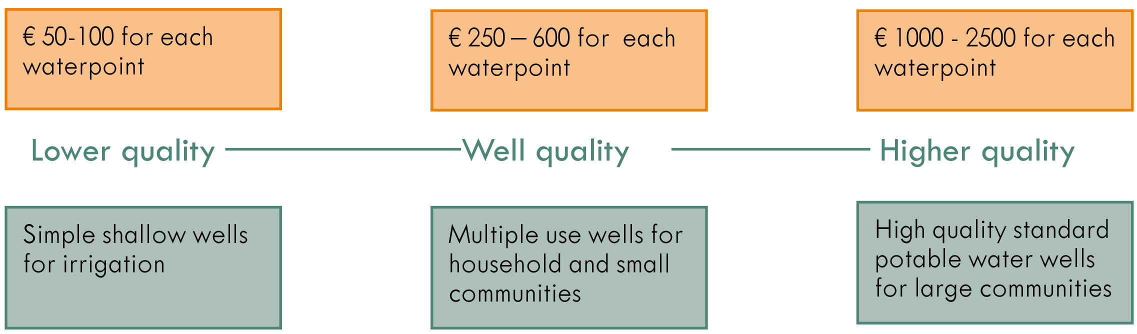
a) For the introduction of shallow irrigation wells the following criteria are very important: The well has to be affordable for the farmer (i.e. low cost materials and shallow), while the water quality is of less importance. A training program in this case will focus on drilling affordable wells, using low cost materials in areas where shallow groundwater exists and where farmers have access to markets to sell their vegetables. Manual drilling enterprises will work directly with farmers.
b) For a professional and sustainable water supply to large communities, the government and larger donors are often involved. The most important criteria here are: a very high quality of the well, high quality of drinking water (meeting all standards), sustainability of the well and sustainability of the whole drilling sector. A training program in this case will require a much larger capacity building road map with its focus on professionalization of the drilling sector as a whole, involving technical training, quality control, business skill training, social mobilization and social marketing. Making manual drilling enterprises ready to respond to large tenders and drilling high quality wells, generally through governments or donors.
c) Multiple use of wells by households and small communities often requires a mix of both previous options: the well should still be affordable (or partly subsidized), but also have an acceptable water quality.

Always realize that the purpose of the well, the water quality, affordability and sustainability go hand-in-hand and that all are important for a right choice of the further approach in training and implementation.

GOING TO SCALE

Once a feasibility study has revealed that there is a high potential for manual drilling in a given area or country

Figure 1. Range of implementation possibilities



and the first team(s) have been drilling successfully, there is potential to scale up the capacity of the sector.

Scaling up is often explained as: training more teams. That is partly what it is, but be careful: training more teams alone is not enough to ensure the quality, affordability and sustainability of wells! When going to scale, not only the drilling enterprises are involved. Other actors play an important role in this process. To visualise this, let's go back to the three examples of the previous page:
a) shallow wells for irrigation, b) high quality communal wells and c) multiple use wells for households.

In all these three examples not only the purpose, quality and price of the wells are different, but also the actors involved. Example b for instance, has its focus on professionalization of the drilling sector as a whole. This involves of course the drilling enterprises, but also quality controllers, the government (responsible for a national quality control system and certification), social actors (to guide communities) and pump suppliers. While in example a, the drilling enterprises, farmer associations and pump suppliers play the biggest role.

Whenever starting a program to go to scale it is important to realize that such a program is not 'a borehole drilling program' only. Going to scale requires a capacity building process with its focus on training, repetition, quality and sustainability of the manual drilling sector. This may take as much as 3-5 years to develop. For an example of a more detailed roadmap on the implementation of larger manual drilling programs please read the manual; **'Professionalizing the Manual Drilling Sector in Africa'** *A capacity building program to increase access to safe water in rural areas.*

THE FIRST STEPS IN ANY MANUAL DRILLING PROGRAM

Feasibility study
A feasibility study will assess the potential for manual drilling and whether it is a practical solution for water supply under the given conditions. Collecting information on hydrology (depth, quality and quantity of groundwater), geology (soil type) and population density will provide a clear indication of areas with the highest potential. It is also of great importance to assess the existing drilling sector. Do manual drilling enterprises already exist? And if so, what is quality of their current work? And what training is required? What are the roles of the other actors involved in the sector such as NGO's, workshops, well diggers, Governments, pump suppliers, etc? This information will be used to determine the right approach for training and implementation, building on- and reinforcing the existing local capacity.

Technical hands-on training on manual drilling
If there is not an existing manual drilling sector present or if there is a need for further improvement of technical skills, a technical hands-on training on a specific manual drilling method(s) is required.

The technical trainer will advise on the purchase of tools and well construction materials and assure that the drilling equipment is fabricated properly. During several weeks a hands-on technical drilling training is given to a team(s) of selected manual drilling trainees. During and after this first training several wells are drilled, allowing the teams to practice and improve their technical skills.

Follow-up and geo-hydrological training
Once teams have gained sufficient experience in the use of the equipment while drilling boreholes, they are ready for the next step: a technical follow-up training combined with a training on geo-hydrology, hygiene, well installation and well development.

Although most existing manual drilling enterprises are very capable of drilling a borehole, a lot of improvements can be made during the construction and development of the wells, resulting in a better water quality, quantity and hygienic use of the well. Most manual drilling teams experience problems with site selection, loss of working water, soil texture determination, logging, well casing installation, well development, water quality and well yield (flow rate of the well). These problems may occur when the drilling process is not completely understood and important steps are missed. The classroom training on geo-hydrology 'Understanding Groundwater & Wells in manual drilling', addresses the above issues. During this training, the drilling team will get a technical follow up training in the field to bring the theory and lessons learnt into practice.

Depending on the size and objectives of a program, additional training can be given on business skills and quality control for manual drilling teams.

4. GETTING STARTED

The construction of a well, using manual drilling techniques is a complicated process. Before drilling starts a good drilling site has to be selected, where experience suggests that there will be an adequate quantity of good quality groundwater. During the drilling process there are a lot of different aspects which require attention to prevent things from going wrong. Besides the practical drilling skills which are executed at ground level, attention also has to be paid to important processes which are happening below ground level during drilling. Water used in drilling (working water) could flow away or worse; the borehole could collapse, burying part of the drilling equipment. And finally, once the hole has been drilled, the well casing, screen and sanitary seals have to be installed at the right depth, preventing contaminated water from entering, and ensuring a sufficient yield. With this in mind, it becomes clear that the introduction of manual drilling needs adequate supervision, with proper training and guidance of the drilling teams.

PREPARATIONS AND THE FIRST TRAINING

Making the drilling equipment

The decision to use quality tools is one of the key factors for success that manual drilling teams can make. Although this looks obvious, the quality of the tools is often overlooked, resulting in loss of equipment and breakdowns in the field. How to avoid this?

All tools and equipment are purchased and made locally. It is important that a good workshop is selected to manufacture the drilling equipment. The workshop should have the right equipment and be skilled to do the job! Module 3 of this handbook has all the technical drawings of the equipment and will guide the workshop during construction. Although it may be expected that the workshop is able to make quality drilling equipment from the drawings, when it is the first time for them, additional supervision is useful. Guidance during construction and quality control of the equipment before it leaves the workshop is essential. At first this quality control can be done by a technical trainer. In a later stage, the drilling enterprises will take care of the quality control themselves.

Training the drilling team

Manual drilling must be understood as a profession that develops through training, hands-on experiences, successes and failures. Technical training sessions by experienced drillers/trainers are an essential base for new teams to become professional manual drillers.

Make a selection of trainees before training starts: It is important that the trainees either have experience or affinity with wells (pump workshops, well diggers) and are motivated to run their own business. On average, a team consists of 5 or more workers and 1 team leader. During several weeks, hands-on technical drilling training is given to the manual drilling trainees. During and after this first training, several wells are drilled. It is good to provide the training and these first wells in an area that consists of loose soils, which are easy to drill. This will allow the team(s) to practise and improve their technical skills, without becoming frustrated.

Important: during this first practice period (a few months) the team(s) will come across problems, may have questions, experience difficult situations or worse may lose some of their equipment. Realize that this is all normal and part of the learning process! It is important that the team(s) are guided well and have access to experienced trainers. After a few months of practise a follow up training will evaluate the problems encountered with the drilling team(s).

GUIDING THE NEW TRAINED TEAM

Drilling in a new area

When a drilling team is new to an area, it is important for them to have information on the geology (soil type) they are going to drill. And how deep they have to drill. In other words: what is the depth of the groundwater and how deep do they need to drill into the groundwater to find a good yielding aquifer?

There are several ways to get this information: Ask villagers to show existing hand dug wells and try to talk with well diggers. They can give information on the different types of formations (soil) and the level of the ground water in dry- and in rainy season.To complement this information; the team should drill its first well to the maximum possible depth. During this exploration, soil sampling will help them to define the depth of a good aquifer. Note that drilling in valley bottoms, floodplains and riverbeds is likely to be more successful than high up in the hills.

Remember; there is NOT a standard for the depth of drilling. This always depends on the depths of an aquifer and the requirements of the users and the pump.

Selecting construction materials

For the well casing different types of PVC pipe are used. The quality can vary from cheap drain pipes with self made filter screens to expensive, high quality factory slotted filter screens and casing pipes.

Around the filter screen a gravel pack or filter cloth is placed to reduce the inflow of fine sand. A sanitary seal is placed to prevent pollution from entering the well. Find more information on construction materials in module 2, chapter 2: What the drilling teams must know.

Finalizing the well

Once installed the well should be further developed to maximize the yield of the well. Then an apron and a pump are placed.

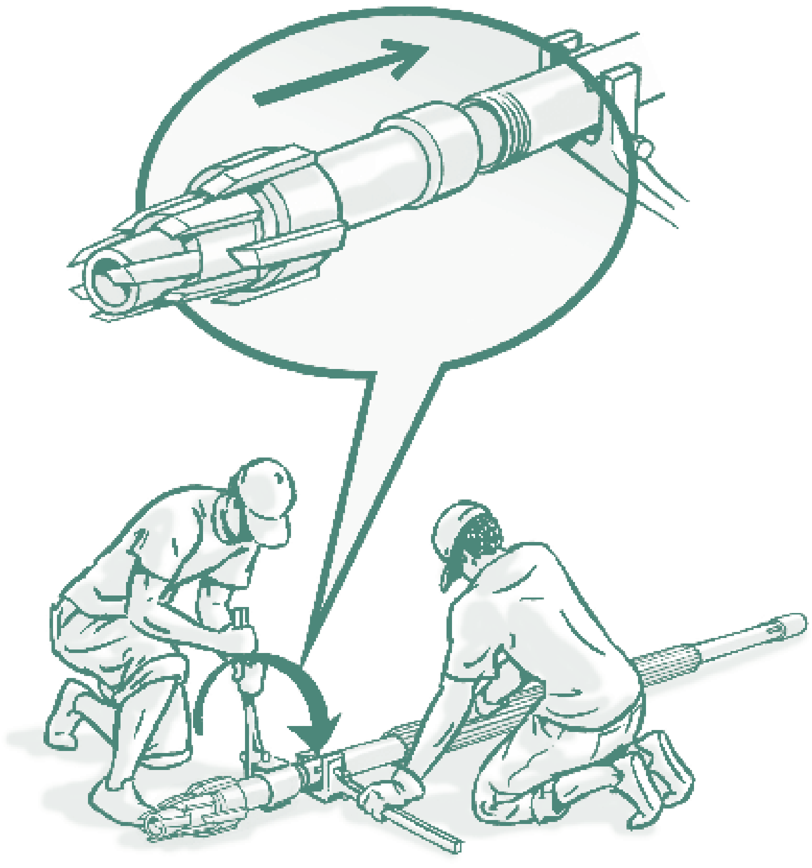
For more details see the manual: **'Understanding Groundwater and Wells in manual drilling'.** An instruction manual on hydro-geology, hygiene, well installation and well development.

Giving a follow up training

When the team has drilled a number of wells and gained practical experience, they are ready for a follow-up training 'Understanding Groundwater and Wells in Manual Drilling'. This training helps them to understand the drilling process and the theory behind it. It will allow the drilling teams to solve problems in the field. During this training, the teams will get a technical training in the field to bring the theory and lessons learnt into practice.

SLUDGING

Module 2



USING THE ROTA-SLUDGE TECHNIQUE

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1. WHAT IS SLUDGING

This second module of the sludging handbook teaches entrepreneurs and technical trainers how to use the drilling equipment and how to drill wells for drinking water using the **sludging technique.**

HISTORY

Sludging, also known as Asian sludging or simple sludging is a traditional drilling technique that originates from Pakistan and is widely used in China, India, Bangladesh and Nepal to drill affordable wells. The name '**sludging'** refers to the use of a drilling mud ('sludge'). The sludge is continuously circulated through the drill pipes, borehole and mud pit during drilling. Sludging exists in many variations that have been developed over time, such as: the Rota sludge, Baptist and Emas drilling methods.

The Baptist method, developed by Terry Waller, uses the sludging principle except that the valve at the top has been replaced by a valve at the bottom in the drill bit. The drill pipes are made of PVC and the up and down movement is created by pulling a rope over a pulley (manually or engine driven). The Emas drilling method, developed by Wolfgang Buchner uses a combination of sludging and jetting.

Rota sludge

The Rota sludge method was developed by Aris van Herwijnen, PRACTICA Foundation. Aris introduced the Asian sludge, observed in North Bengal India, in Nicaragua in 2001. However, drilling teams had difficulties using the Asian sludge when they had to drill in compact and consolidated formations. To drill through these layers, a drill bit was developed and a rotation movement added, giving it the name "Rota" sludge. A Rota sludge driven by engine, called the Maq-Perfor, has recently been developed and tested in Nicaragua.

This practical module is created with information compiled from available literature, field observations in Latin America, Asia and African countries, discussions with local drilling teams and interviews with sludging experts. This manual is an updated version of the existing manual "Rota sludge and Stonehammer drilling", written by Aris van Herwijnen, PRACTICA Foundation 2005 and includes lessons learned in Rota sludging in the past 5 years and a modification of tools and equipment.

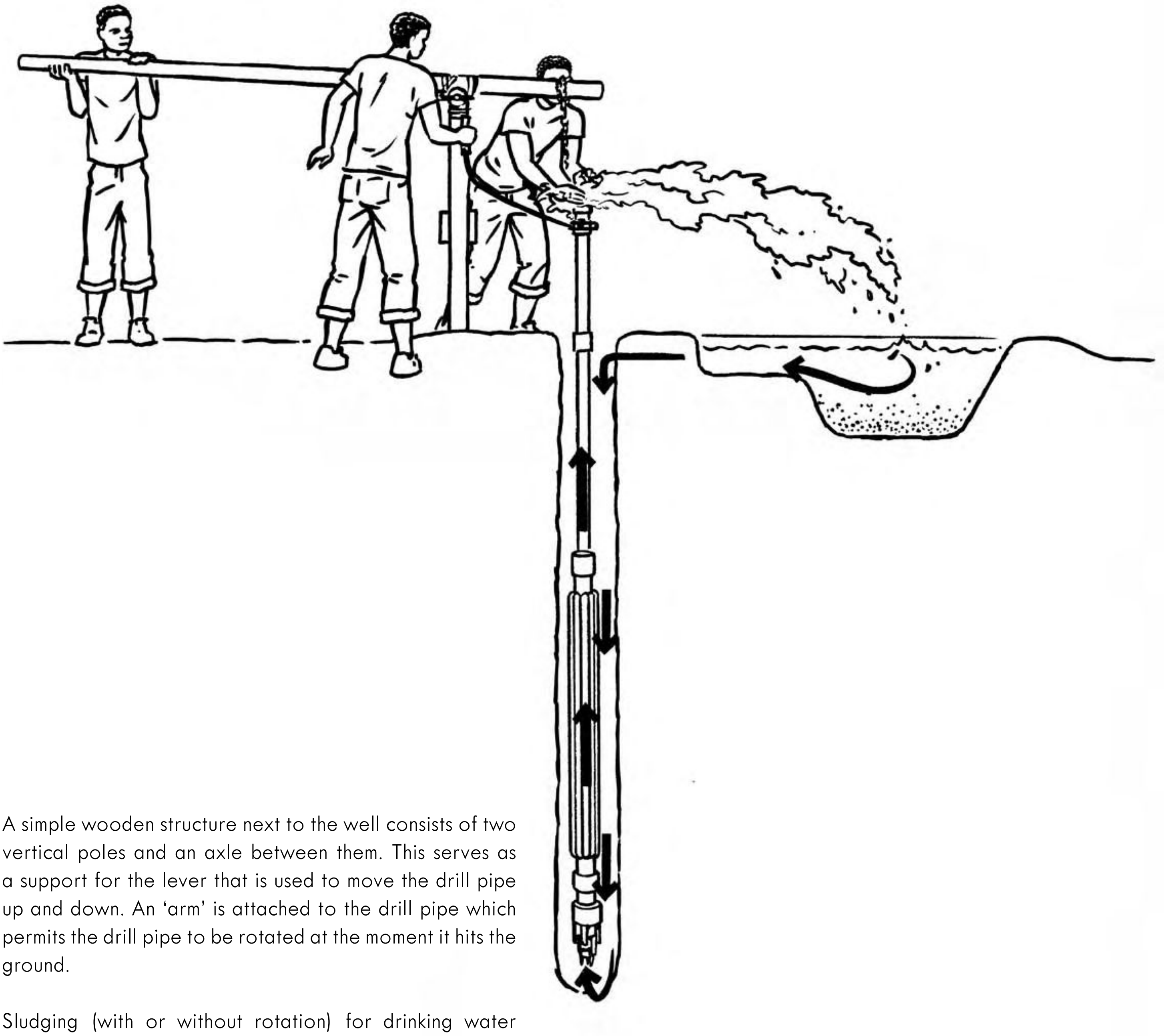
Nowadays the Rota sludge method is being used in: Nicaragua, Madagascar, Tanzania, Ethiopia, Uganda, Ghana, Liberia, Niger, Senegal and Mauritania.

This module summarizes best practices in drilling with the Rota-sludge technique.

HOW DOES IT WORK?

A Rota sludged well is a borehole that is drilled into the ground using water circulation to bring the cuttings up to the surface. The drill pipes are moved up and down and rotated by human power. On the down stroke, the impact and the rotation of the drill bit loosens the soil. On the up stroke, the top of the pipe is closed by hand (or valve), drawing up the water through the pipe and transporting the cuttings to the surface. On the next down stroke, the hand (valve) opens the top of the pipe and the water squirts into a pit, in front of the well. In this pit, the cuttings separate from the water and settle out, while the water overflows from the pit back into the well. As the drilling progresses, more pipes are added

The borehole is kept full of water at all times to prevent the well from collapsing. Thickeners (additives) are added to the water to plaster the borehole wall in unstable formations and to make a drilling fluid. Drilling fluid helps to bring the drilled material up to the surface and reduces loss of water.



A simple wooden structure next to the well consists of two vertical poles and an axle between them. This serves as a support for the lever that is used to move the drill pipe up and down. An 'arm' is attached to the drill pipe which permits the drill pipe to be rotated at the moment it hits the ground.

Sludging (with or without rotation) for drinking water wells is generally used up to depths of about 35 meters on average, and exceptionally deeper in soft formations.

Where does it work?

Sludging is suitable for unconsolidated formations: Sand, silt and clay. If rotated (including a drill bit) it may be possible to penetrate softer-consolidated formations such as stiff clays, soft sandstone, tuff stone and weathered laterite.

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ADVANTAGES & DISADVANTAGES

Advantages of Rota sludging

The drilling tools and equipment can be constructed and repaired in local workshops and are easy to transport in rural areas. Rota sludging is useful in a large range of soil formations and especially effective in sandy-clay soils, which are difficult to drill with the jetting and augering methods. With sludging, water circulation brings the cuttings up to the surface continuously; there is no need to bring up the drill bit to empty it.

Disadvantages of Rota sludging

To prevent the well from collapsing, fluid-drilled boreholes must be kept full of water during the entire drilling and well installation process. Coarse gravel and other highly permeable materials (cracks in the formation) cause loss of working water and cannot be drilled. ,

2. WHAT DRILLING TEAMS MUST KNOW

BEFORE YOU START DRILLING

Before you start drilling, there are some important things you need to know. First; a drilling site needs to be selected, where a good quantity (high yield) and quality (no pollution) of groundwater is expected. Second; some knowledge of construction materials such as PVC casings and also of soil sampling and drilling safety could help you to become a better driller.

Selection of the drilling site

Selecting a good location for the well is not always easy and depends on: needs and preferences of the users, expected groundwater level, type of formation (soil) and any nearby sources of pollution (latrines) that may be harmful.

Some tips to help you in site selection:

- The needs, preference and ideas of the users should be placed first when you select a location.
- Always discuss advantages and disadvantages of the selected location with the users (you are a specialist who has knowledge about the expected quantity and quality of water in relation to the selected site).
- Ask villagers to show existing hand dug wells and try to talk with hand diggers. They can give useful information on the different types of formation (soil) and the level of the ground water in dry- and in rainy season.
- Note that drilling in valley bottoms and riverbeds is likely to be more successful than high up in the hills. Keep in mind that the selected site is not flooded during the rainy season (if it is the lowest point in the landscape).
- Always choose a site at least 30 m away from a latrine. Avoid other possible sources of pollution such as waste dumps, fire places and fuel stations.

MATERIALS

What about the PVC pipes?

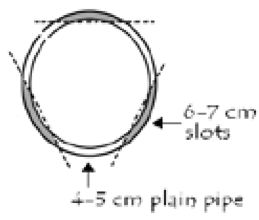
For the well casing, you can use different types of PVC. The quality can vary from cheap drain pipes with self made filter screens to expensive, high quality factory slotted filter screens and casing pipes. The choice of pipes depends on: diameter of the pump (the pumps should fit the pipe), type of the well (irrigation or potable water), user intensity (household or communal) and the users budget (low or high).

Buying the pipes

You can buy high quality factory slotted pipe in a specialized hardware store. The pipe has a thick wall, is strong and has a lot of slots per meter filter screen, resulting in a high water inflow. The pipes are expensive and are often used for large communal wells. You can also buy cheaper PVC pipes. You can find these regular pipes in almost each hardware store. The wall thickness should be 3 mm or more to prevent the pipes from breaking. In this case you have to make the slots of the filter screen yourself.

Making the slots in the filter screen

Use a hacksaw to make slots in the pipe. For a 4-inch screen, 6 parallel lines are drawn along the full length of the pipe. The spaces between the alternate lines should be about 4-5 and 6-7 cm (see drawing). The slots are sawn between 6-7 cm lines. The distance between the slots should be about one centimeter. Guideline: the length of the filter screen should be at least 3 meter. The last meter of pipe has no slots. This is called the sump in which fine particles that enter the well screen can settle, without blocking the filter screen. The bottom is closed with a PVC cap or by cutting and bending the bottom of the PVC pipe.



Gravel pack

Coarse river sand in the range 1.5-3 mm is used as a gravel pack. The gravel pack fills the space between the borehole wall and the filter screen. It may also serve to filter some of the fine sand particles from entering the well. Use a minimum and a maximum sized sieve to prepare the 'gravel'.

Sanitary seal

During installation a sanitary seal is placed on top of the gravel pack to prevent pollution entering the well. A sanitary seal is made of clay or cement grout. If cement is used for the seal, first a half meter of clay is backfilled on top of the gravel pack to prevent the cement from penetrating the gravel pack.

Drilling fluid

Although it sounds dirty, cow dung can be used as an additive to the water to create a drilling mud. This works very well, is biodegradable, free of cost and generally widely available. One requirement is that it has to be fresh, collected the same day when you are drilling. Cow dung and E-coli (bacteria in the cow dung) can be removed during well development and chlorination of the well when drilling is finished. Other additives can be used as an alternative, such as natural clays, fibers and although more expensive, natural polymers. Natural polymers are also biodegradable; in other words, after some time they disappear naturally. Additives need to be removed when the drilling is finished. Please find more information on additives and how to remove them (well development) in the manual **'Understanding Groundwater and Wells in manual drilling'.**

TO REMEMBER DURING DRILLING

Take soil samples

Soil sampling helps you to understand what material you have been drilling through and helps you to indicate when you have reached the final depth of drilling

This sampling is also a good way to determine how easily water flows through the pores (open space) of the drilled material. Sand and gravel are very permeable, and are therefore suitable layers which transmit the water easily. If the drilled material is very fine, such as silt and clay, it will not transmit water easily and is called impermeable. Do not install the filter screen in this formation.

Field tricks

Take a sample of the soil and squeeze it into a ball, between your hands. Then drop the ball from a height of one meter above ground level.

- If the ball consists of non cohesive (non-sticky) particles, the ball totally falls apart. In this case the material is permeable. The particles of sand or gravel will be easily visible.
- If the ball falls apart only partially, the soil contains some silt or clay and sand. The formation has a low permeability.
- If the ball only deforms and remains more or less in shape, it is composed of clay, and is described as impermeable.

Drilling safety

Keep the borehole full of water at all times! A frequently made mistake is to go for lunch, without keeping an eye on your working water. When you come back, the water level in the borehole has dropped, the hole has collapsed and your **equipment is lost!**

When you have to leave the site overnight during drilling, you need to take important precautions:

- Lift up the pipe at least 3 meters in the borehole or take it out. This will prevent the drilling pipe from getting stuck.
- Always keep your borehole full of water, also during the night. This is necessary to prevent the borehole from collapsing.
- Protect the borehole and the mud pit. Take measures to prevent cattle from stepping in

Please be aware that drilling can be a dangerous activity. Watch each other and ask villagers (especially children) to watch you from a safe distance. This prevents them from accidentally being hit by the lever or one of the drilling pipes.

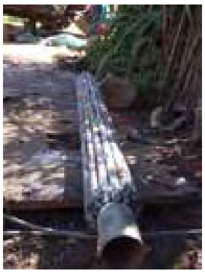
NOTE

These are a few guidelines to help you during drilling. You can find more information on soil, groundwater, hygiene, sampling, well installation and well development in the manual **'Understanding Groundwater and Wells in manual drilling'.**

3. WHAT TO BRING

Tools & materials

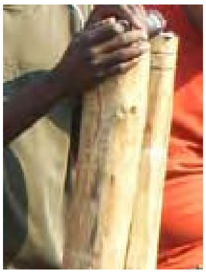
Drill pipes (17 x 1,5 meter)
+ (2 x 0,75 meter)



Weighted pipes
(2 x 1,5 meter)

Drill bit (1 or 2 pieces)

Rotation arm (1 piece)



Frame poles (2 pieces)

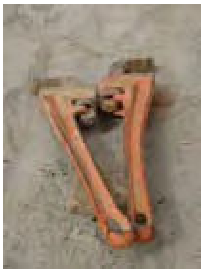
Wooden planks (2 pieces)

Axle (1 piece)

Lever (2 pieces)

Half bush (1 piece)

Hacksaw (2 pieces)



Pipe wrenches (3 pieces)

Shovel (2 pieces)


Toolbox (full)


Bucket 12 liters (2 pieces)


Empty oil drums
(200 liters) (3 pieces)


Sieves 1,5 & 3 mm
(2 types)


Additives (1 bag)


Inner tube (2 meters)


PVC casing pipe


PVC glue


Sieved gravel pack
(50 kg bag)


Depth measuring tool
(1 piece)


Hand auger (3 meters)


Rope, 15 mm (1 meter)


Rope, 6 mm (5 meters)


Chain, 6 mm (1,5 meter)


Bolt and nut, 8 x 60 mm
(4 sets)


Nails 10 cm (10 pieces)

4. HOW TO DRILL A BOREHOLE
WITH THE ROTA SLUDGE

STEP 1 SETTING UP THE RIG

Dig holes for the frame
Dig 2 holes of 80 cm deep for the poles of the frame. The distance between the holes should be about 30 cm.

Tip
Use a steel bar or hand auger.

Measure the height of the poles

Place one of the poles in the hole. The top of the pole should be equal to the shoulder height of the team members.

Place the frame poles

Place a large flat stone at the bottom of each hole and put in the frame poles.

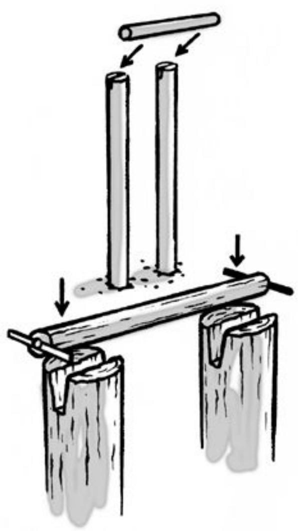
Tip
Put small stones around the poles and tamp the stones with a wooden stick to place the poles firmly into the hole.

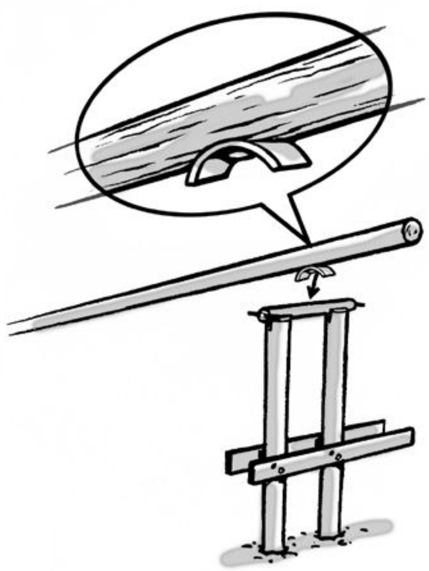
Place axle and lever

1. Place the axle on the frame poles.

2. Place the half bush with a nail.
   Place the lever on the axle.

3. Attach two wooden planks between the poles
   (50 cm height)

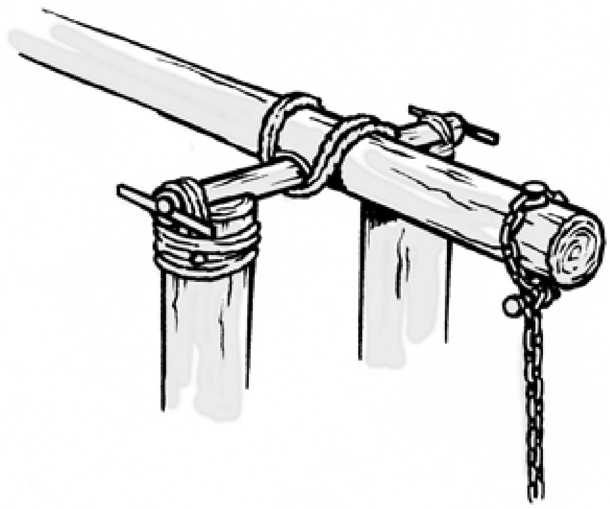




Tip
The distance from the half bush to the end of the lever is the same as the length from your elbow till the tip of our fingers (about 40 cm)

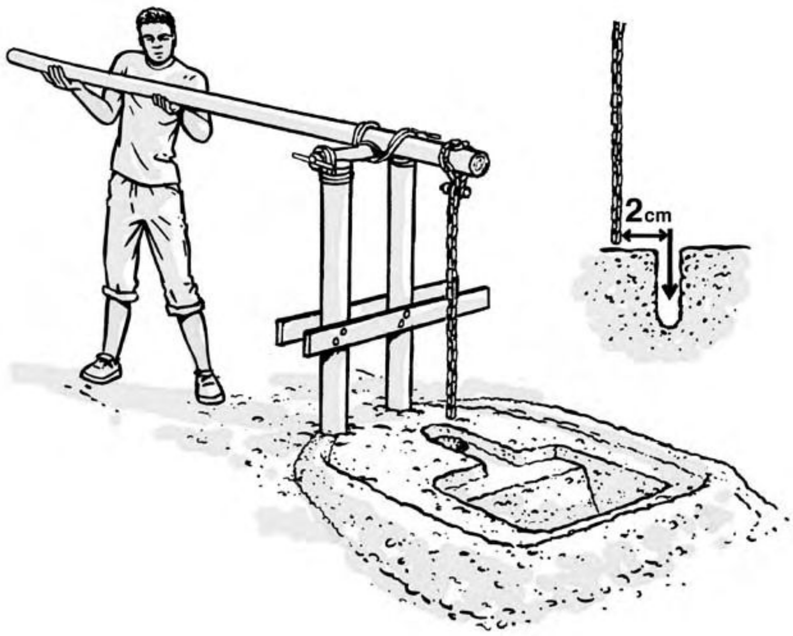
Connect the lever and chain

1. Turn a thick nail in the frame poles and ty a 15 mm rope around the lever, axle and frame poles to make a tight connection.
2. Attach the chain to the lever at a distance of 35 cm from the axle using a bolt and nut. Turn a thick nail in the lever. This will prevent the chain from slipping off.



Mark the position of the well

Let the chain touch the ground when the lever is in a horizontal position. Make a mark on the ground 2,5 cm to the right (facing the rig from the front, see picture). This will be the centre point of the well.



Make a starter hole

Make a starter hole of at least 1,5 meters deep at this centre point using a steel bar or a hand auger.

Tip

If you have the tools, make a starter hole of 2-3 meters deep. This will make the circulation easier.

STEP 2 PREPARING THE MUD PIT

Dig the mud pit
Dig the mud pit and surround the mud pit with a dyke. The mud pit consists of a shallow part and a deeper part. Connect the mud pit and the starter hole with a channel.

In the deeper part of the mud pit the drilled material will separate from the drilling water.

Plaster the mud pit
Seal the mud pit and channel with clay or drilling fluid (water + additive) to conserve your water. In sand or in dried clay (cracks) water will leak away easily.

What about the water supply?
Fill the mud pit and starter hole with water from a nearby well or river.

Make sure you have water all day! You will loose water during drilling.

Make drilling fluid
Mix additive to the water until the water is getting thicker.

Drilling fluid helps to bring the drilled material up to the surface and reduces loss of water and the chance of collapse.

Tip
Estimate how much water you will need for a day's drilling. Make sure you have more than enough.

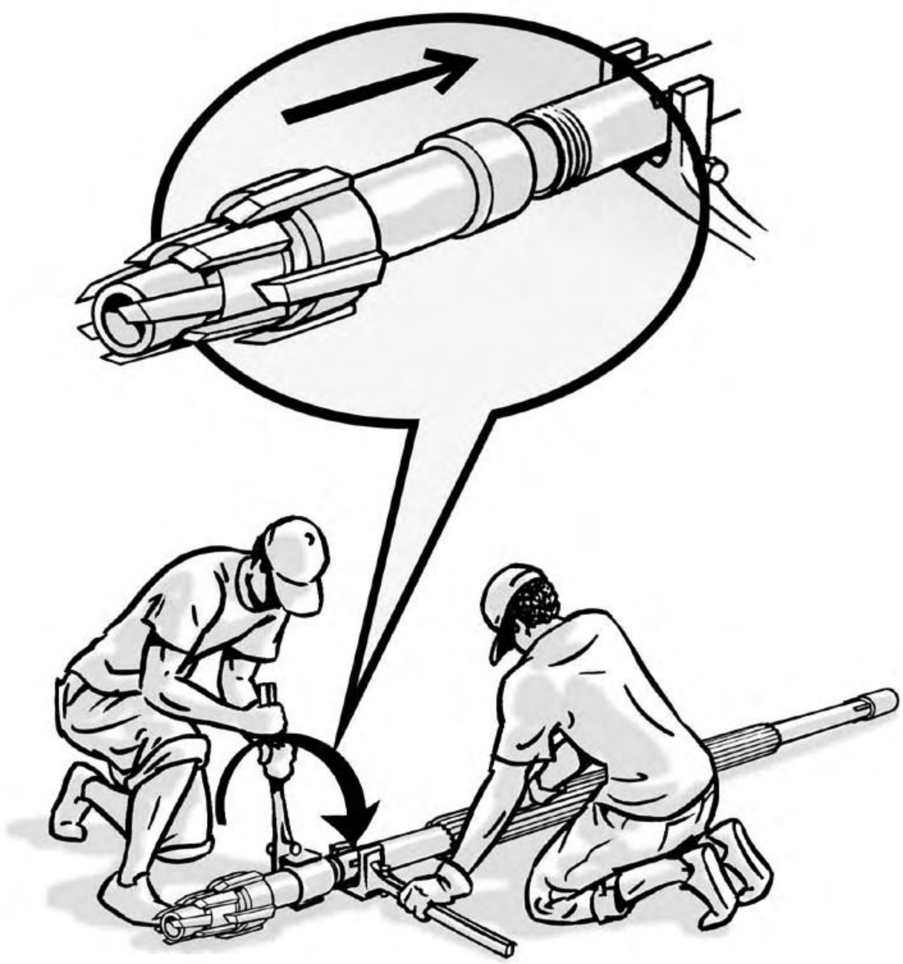
Tip
When you are losing a lot of working water or the drilled material is not coming up, more additive can be mixed.

Tip
Cow dung works extremely well as additive and is cheap. Mix fresh cow dung with water in a barrel until it is a soft mixture without chunks. You can use this as additive.

STEP 3 PREPARING THE EQUIPMENT

Connect the drill bit to the weighted pipe

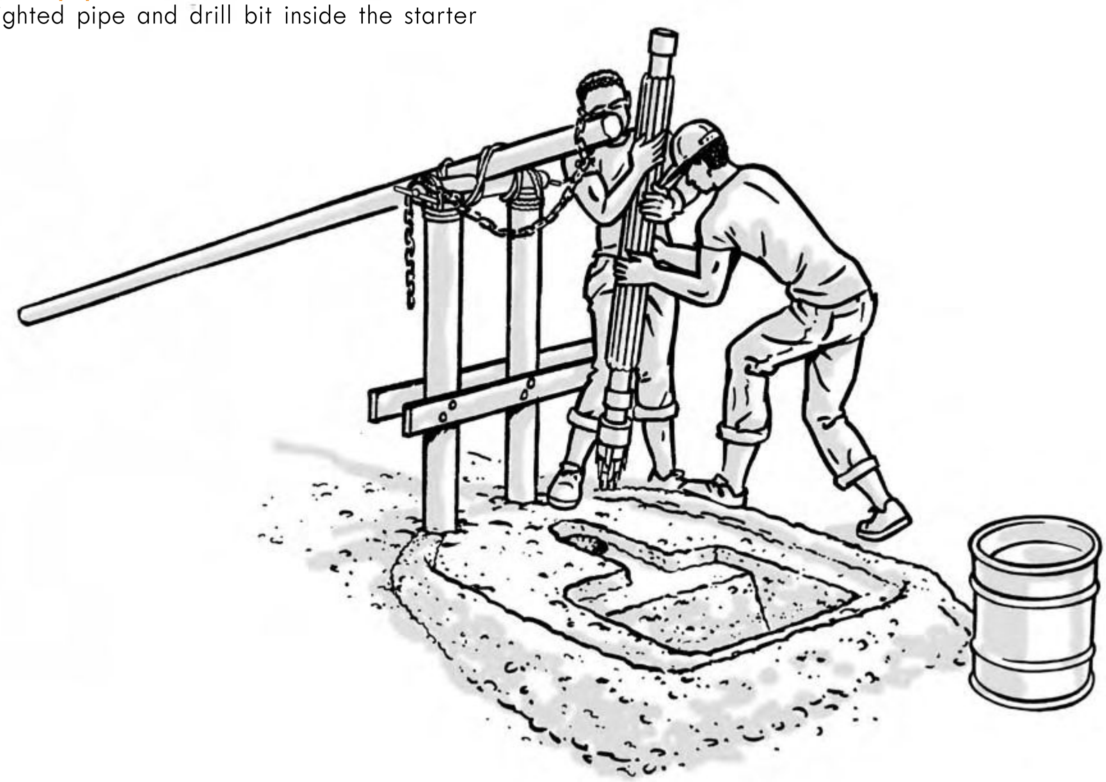
Connect the drill bit to the weighted drill pipe using the pipe wrenches.

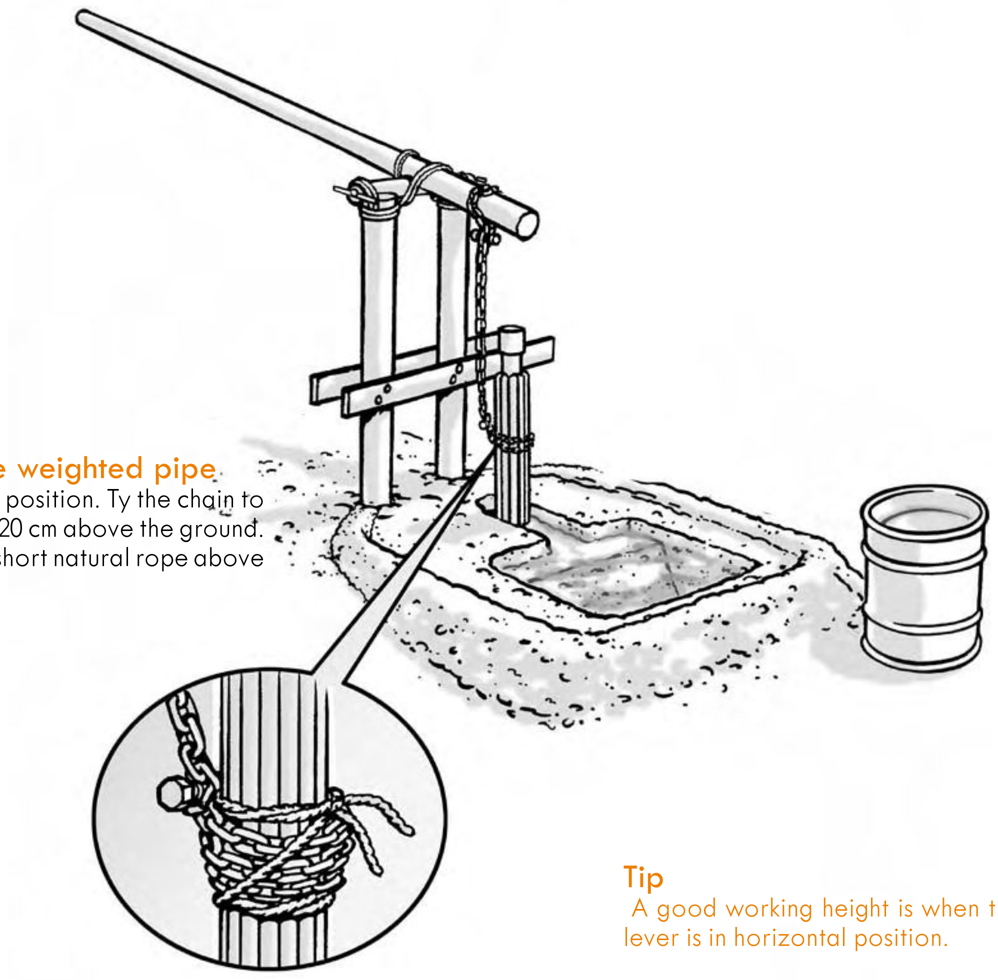


Tip

Keep threads clean with a steel brush and protect threads during transport to prevent damage.

Set up the drill pipe
Place the weighted pipe and drill bit inside the starter hole.



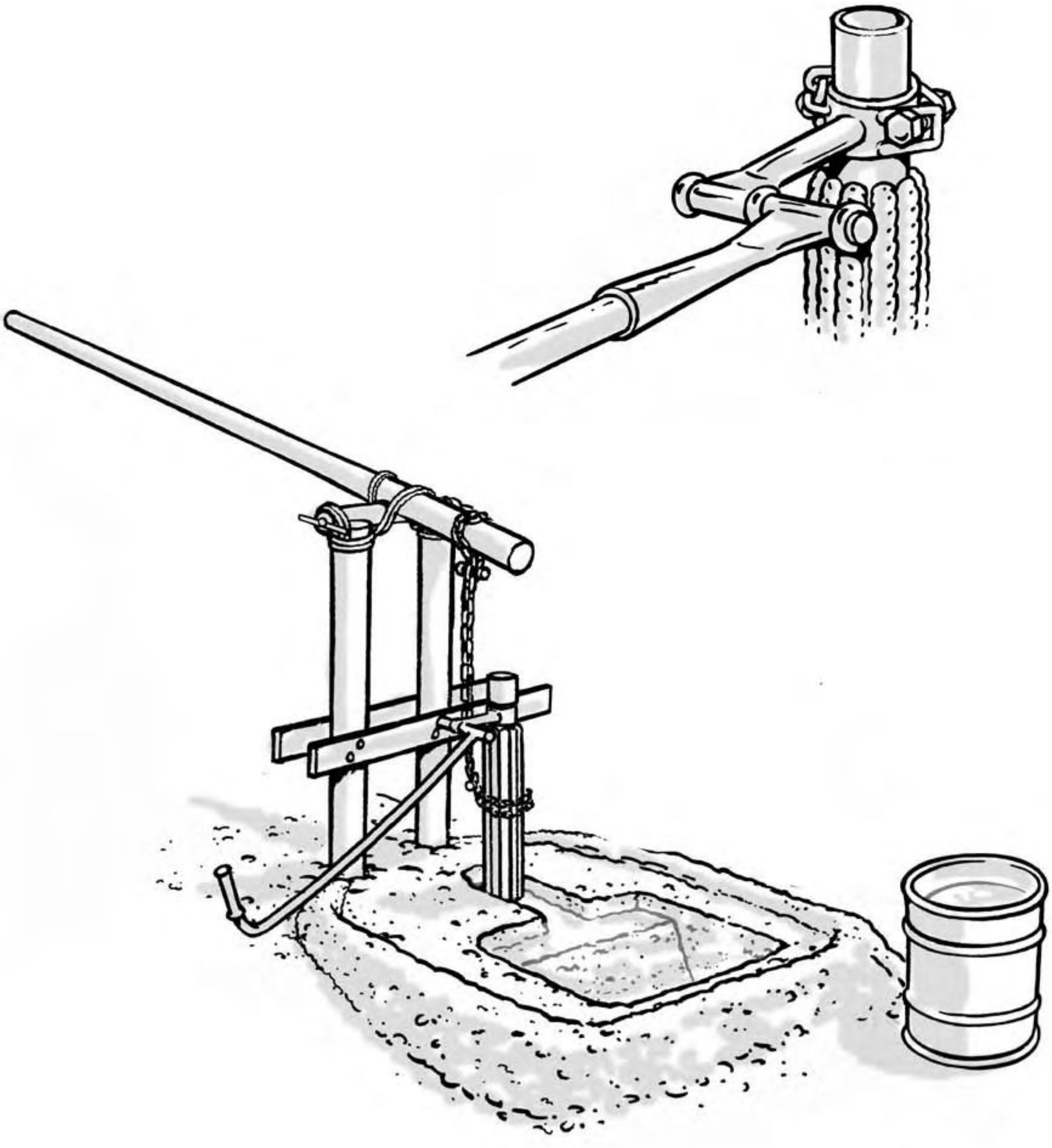


Attach the chain to the weighted pipe
Hold the lever in horizontal position. Ty the chain to the pipe with a bolt and nut 20 cm above the ground. Secure the chain by tying a short natural rope above and below the chain.

Tip
A good working height is when the lever is in horizontal position.

Attach the arm illustratie nr10:

Attach the arm to the top of the weighted pipe. Now drilling can begin.



STEP 4 PREPARING TO DRILL

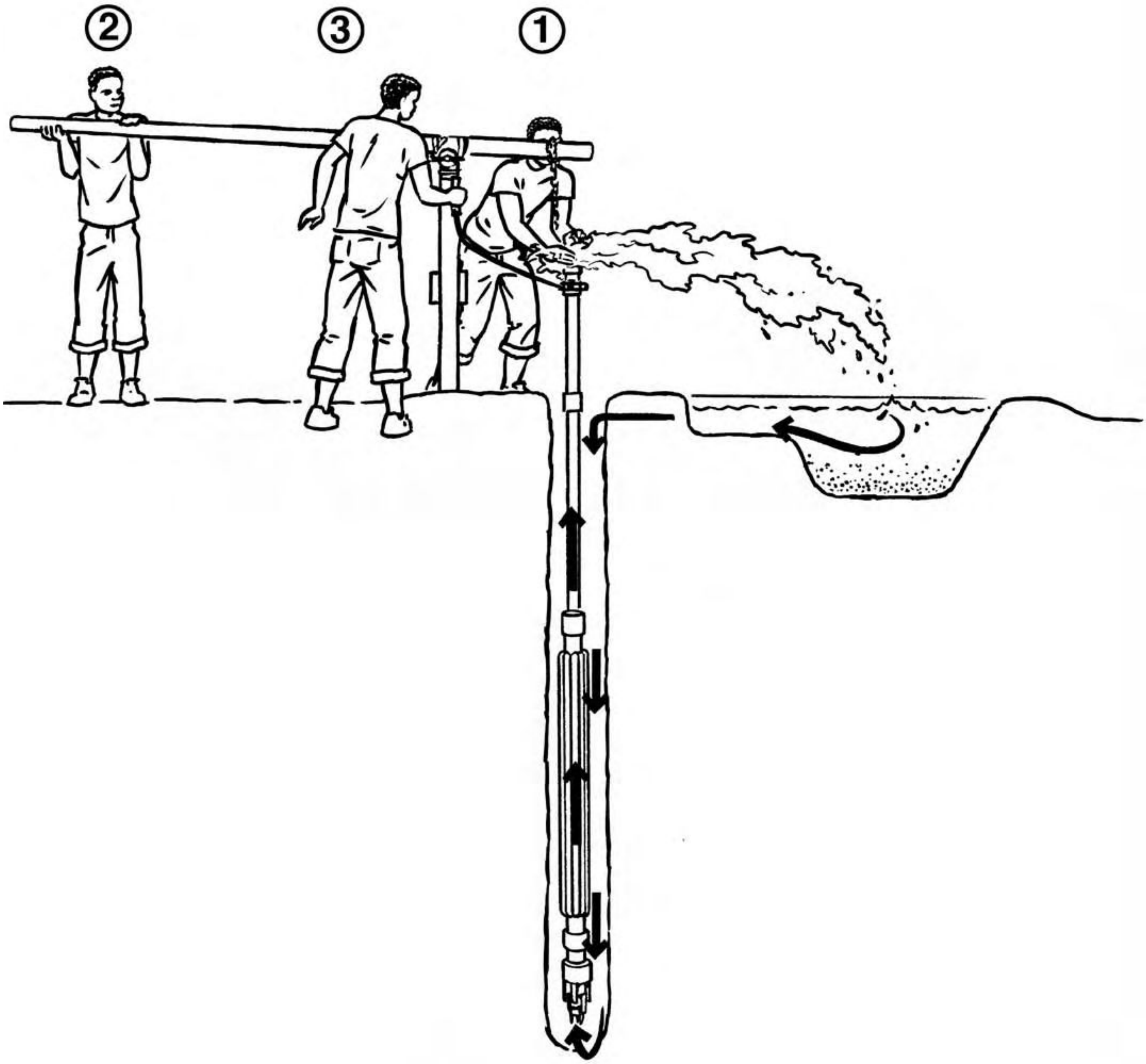
The drilling team

The work consists of three tasks;

1. The driller - controls the water flow with his right hand and is coordinating the team. The driller is standing next to the drill pipe, facing the mud pit.

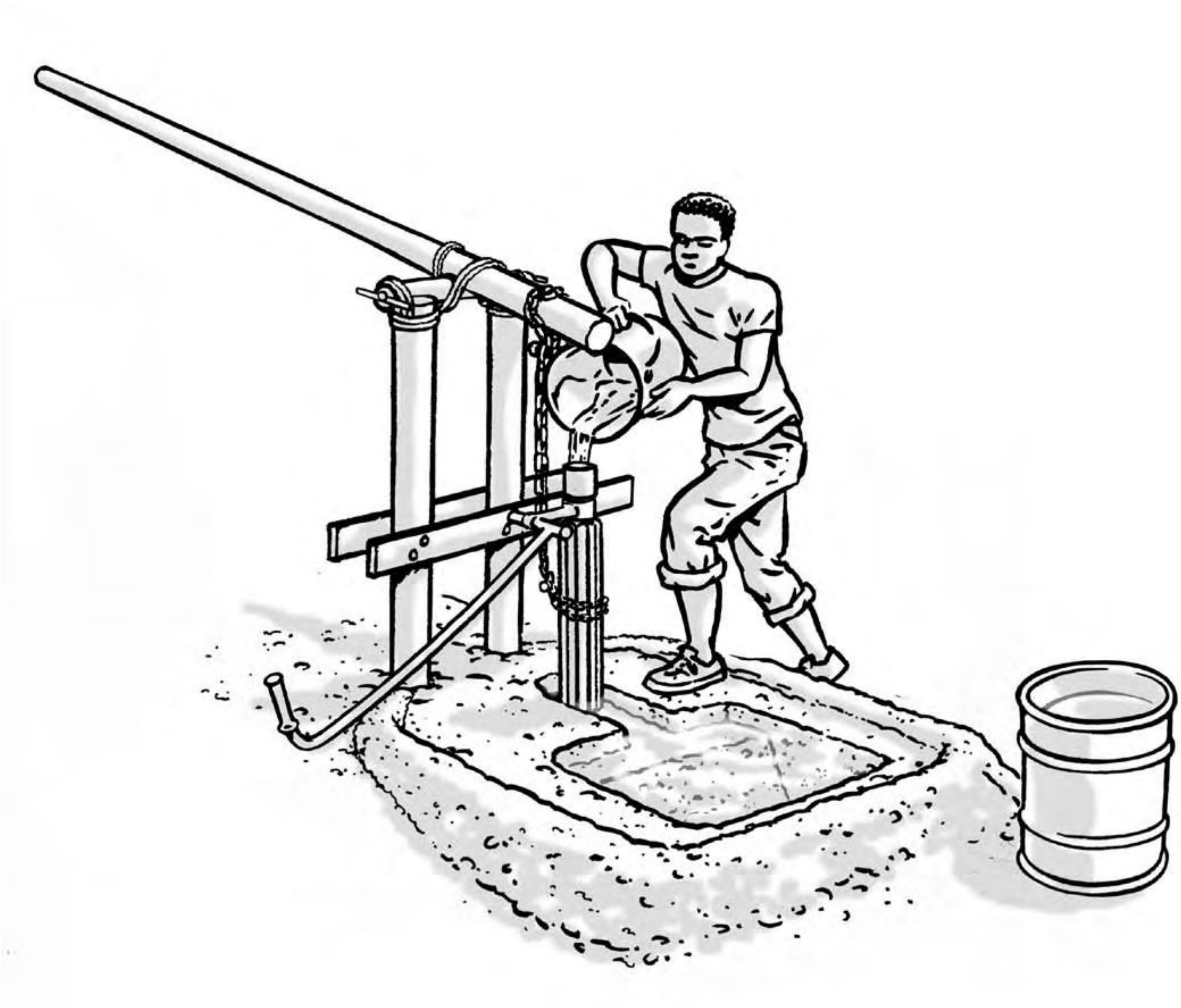
2. The lever operator(s) - lift and drop the drill pipe by moving the lever up and down.

3. The arm operator - rotates the drill pipe and drill bit. He is facing the driller.



Fill the drill pipe with water

Pour water into the drill pipe until it is filled and close the pipe quickly with your hand. Now sludging can begin.



Tip

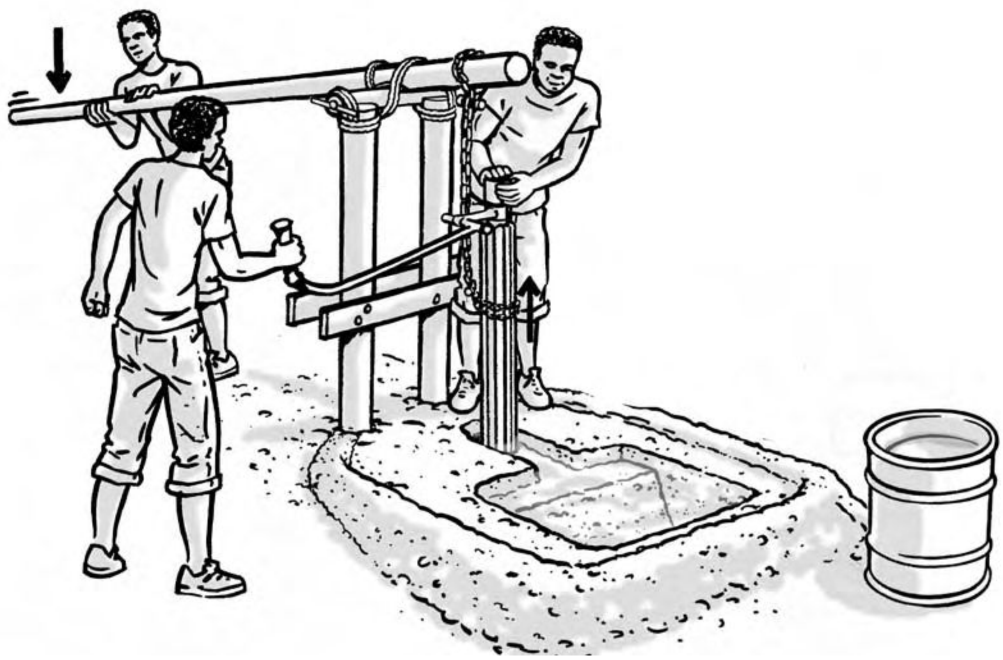
In the first meters of drilling it is difficult to maintain circulation. Fill the drill pipe with water each time you start to circulate. This will make it easier.

STEP 5 STARTING TO DRILL

Circulate the water

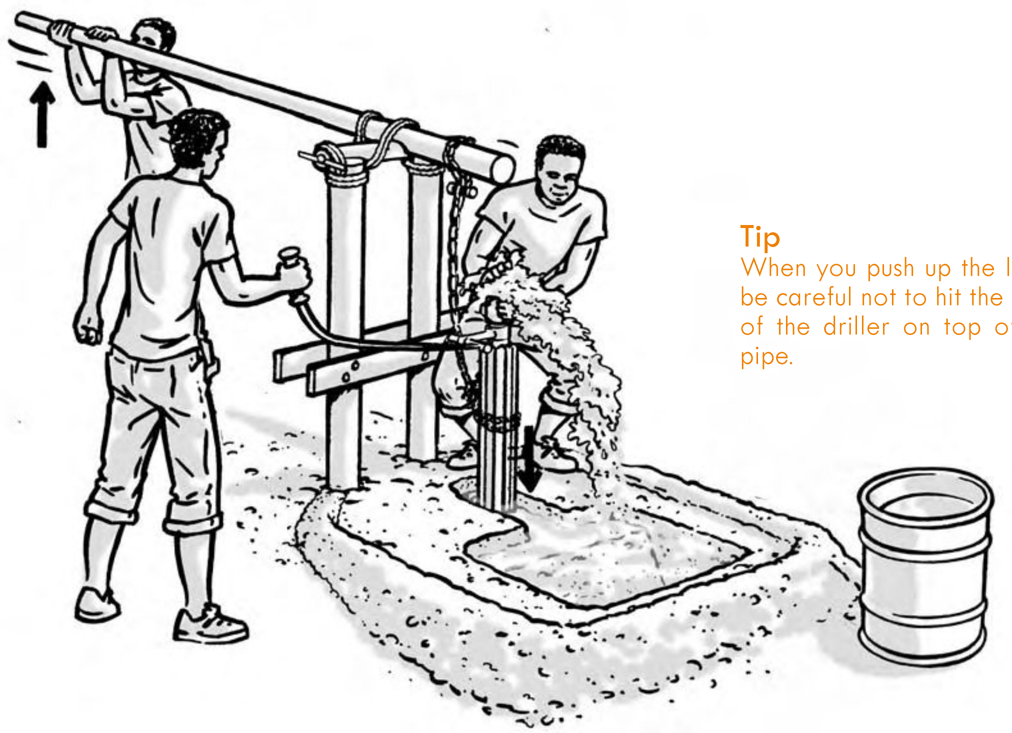
1. Close the top of the pipe with your hand.

2. Move the lever down (lift up the pipe)



3. Push the lever up with high speed (let the drill pipe make a free fall).

4. Open your hand. The water is now forced out the pipe. Aim the sludge back into the mud pit.



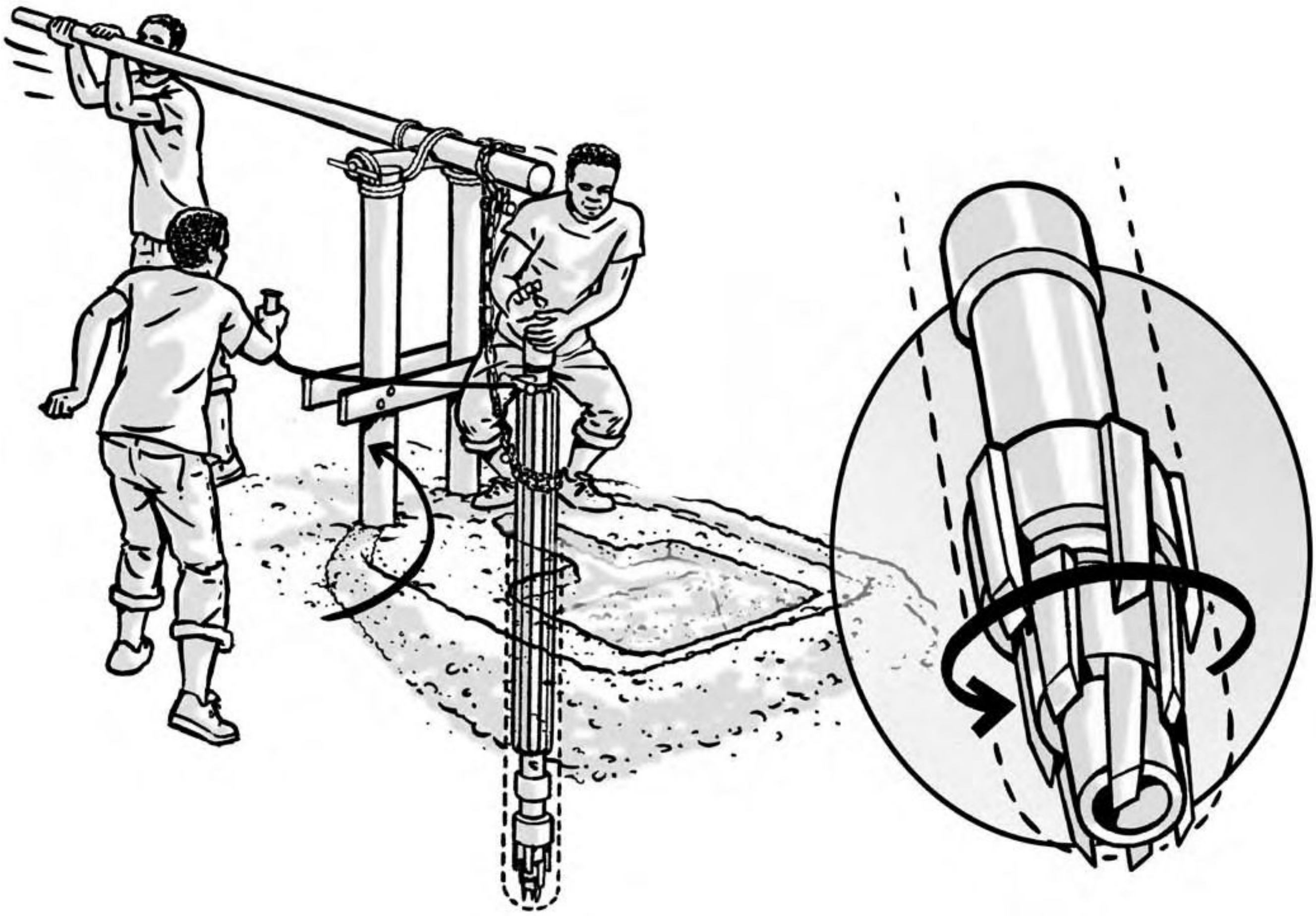
5. Then close your hand and start the cycle again.

Tip

When you push up the lever, be careful not to hit the hand of the driller on top of the pipe.

The rotation movement

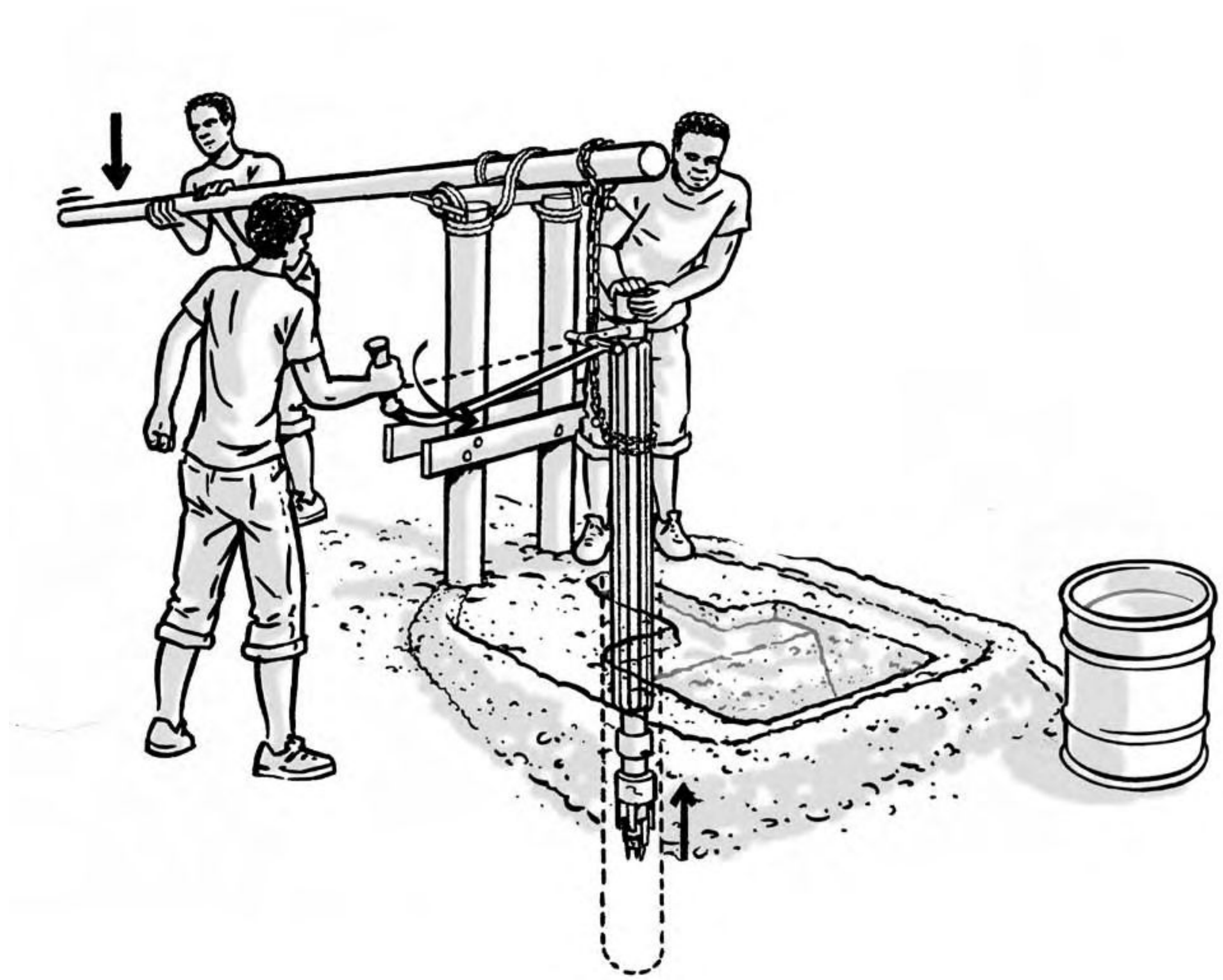
1. Move the lever down (lift up the pipe).
2. Push the lever up with high speed (let the drill pipe make a free fall).
3. Rotate the arm after the drill bit has hit the bottom. Rotate the arm a quarter of a turn from the right to the left (clockwise).



4. Move the lever down again (lift up the pipe)

5. Rotate the arm back to the starting position (left to right).

Only move the arm back to the right when the drill bit is off the bottom to prevent the threads from being unscrewed (turning loose).



The complete drilling cycle

1. Close the top of the pipe with your hand.

2. Move the lever down (lift up the pipe).

3. Push the lever up with high speed (let the drill pipe make a free fall).

4. Open your hand. Aim the sludge back into the mud pit.

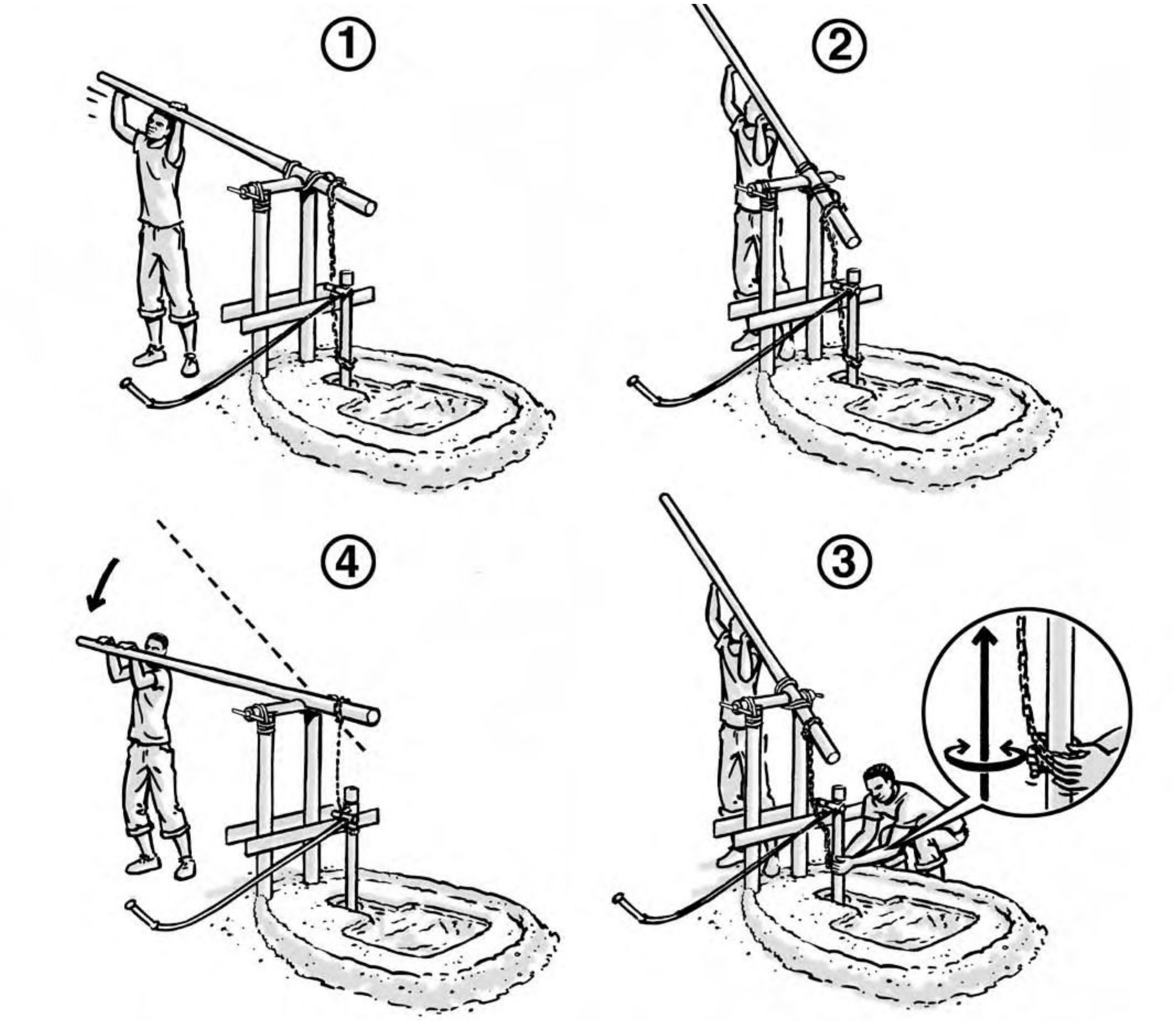
5. Rotate the arm after the drill bit has hit the bottom.

6. Close the top of the pipe, move the lever down again and rotate back the arm.

STEP 6 DRILLING DEEPER

Move up the chain

A good working height for the lever is a horizontal position. When you drill deeper, the lever will go up and becomes to high to reach. You now need to move up the chain on the drill pipe to adjust the height of the lever.



1. The lever becomes to high to reach.

2. Push the lever up, to give slack in the chain.

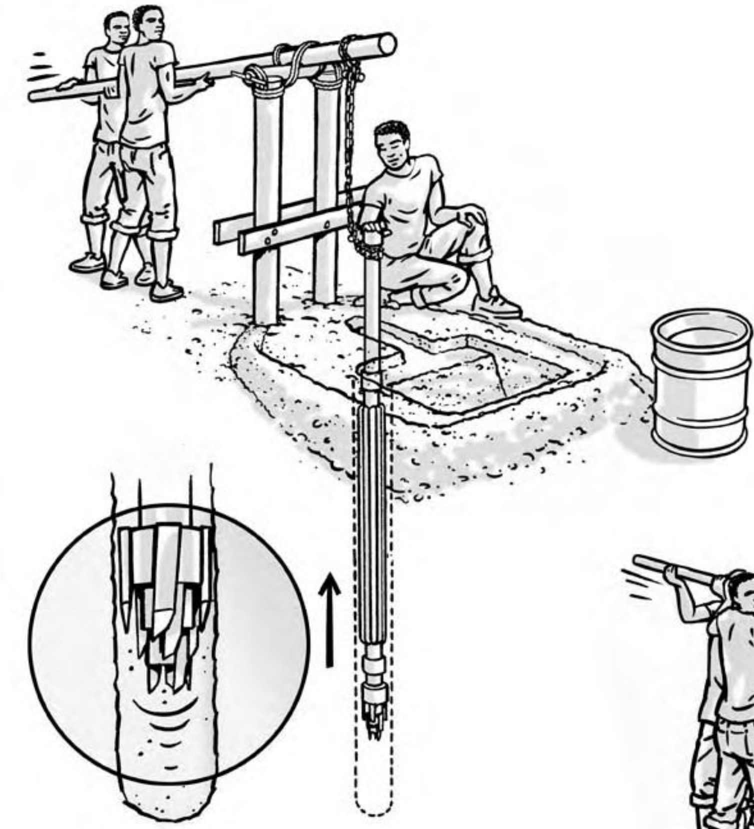
3. Slide the chain up the pipe (do not put tension on the chain with the lever).

4. Place the lever back in horizontal position. You have now adjusted the working height.

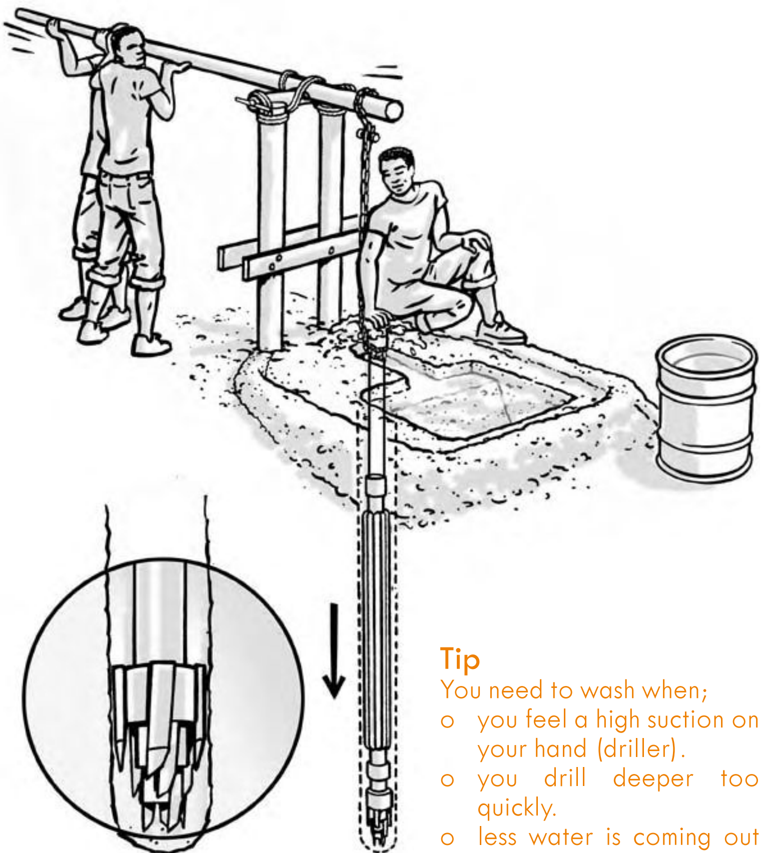
STEP 7 MAKING A TEMPORARY STOP & ADDING A NEW DRILL PIPE

Wash the borehole

During drilling, a lot of cuttings are drilled loose from the bottom of the borehole. Wash the borehole to remove the cuttings.



1. Move the lever up and down continuously, do not drill any deeper!
   (do not hit the bottom of the borehole)
2. Circulate the sludge until all cuttings have been removed. (do not rotate the arm)



Why do you need to wash?

During drilling a lot of cuttings are mixed with the water in the borehole. If there are too much cuttings, the drill pipes will be blocked. Or worse; when you stop drilling, the cuttings will sink down on top of the drill bit and you can lose your equipment!

Circulate until the sludge is free of cuttings, only then it is safe to stop.

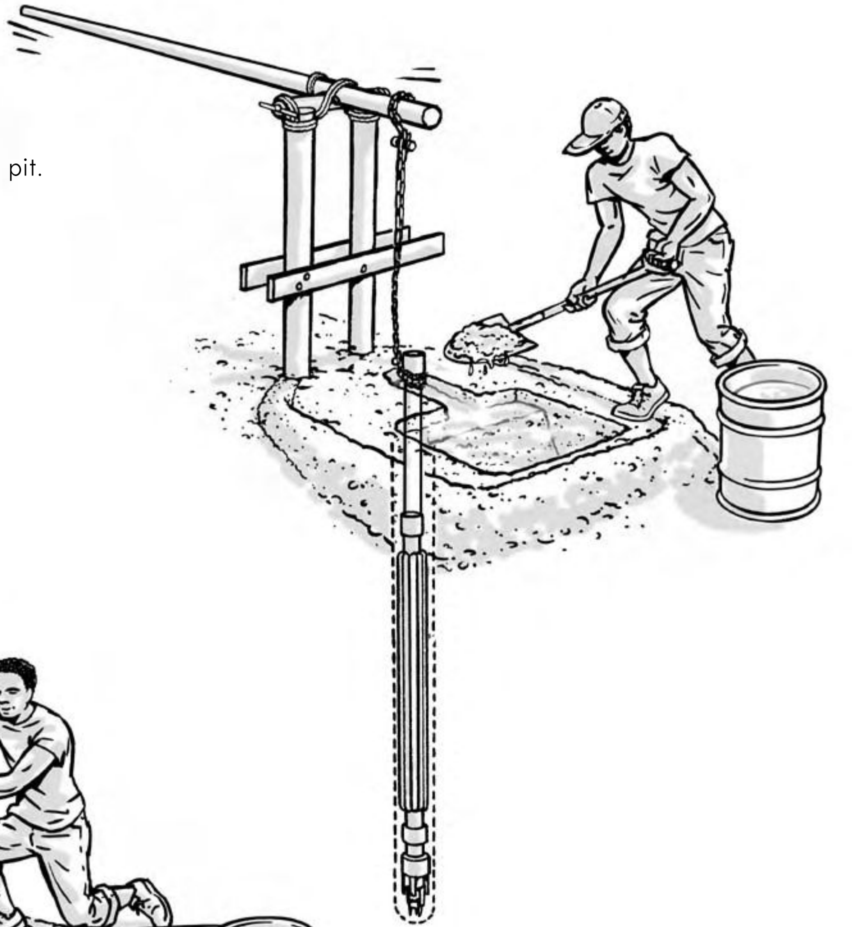
Tip

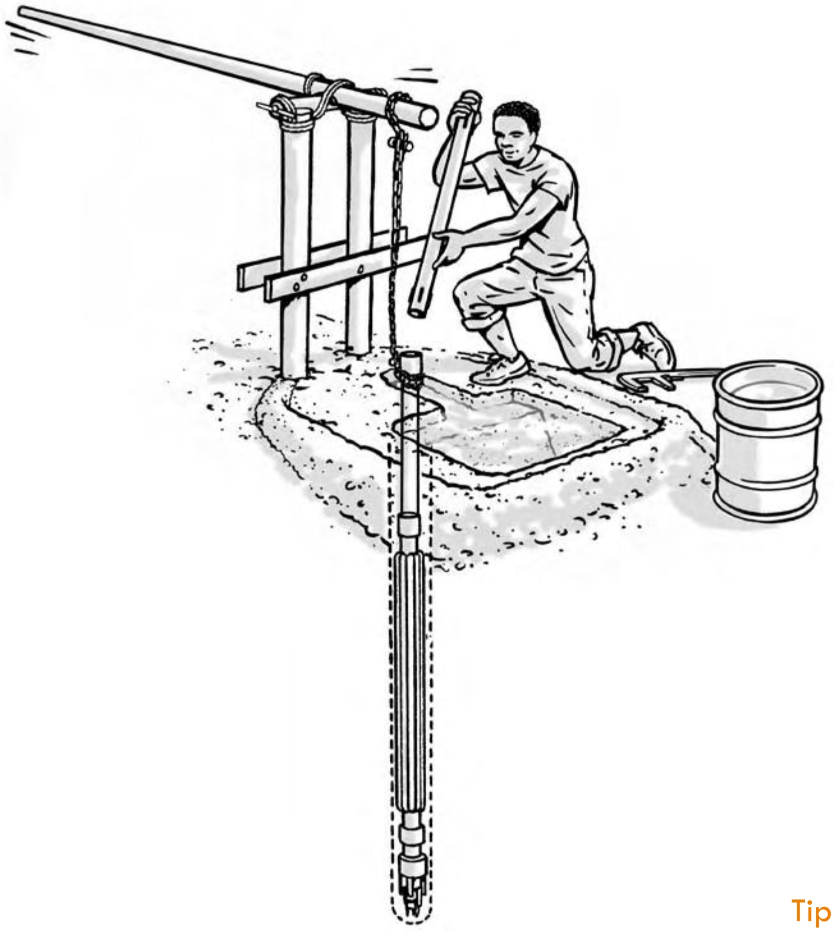
You need to wash when;

- o you feel a high suction on your hand (driller).
- o you drill deeper too quickly.
- o less water is coming out of your drill pipe during circulation.
- o each time before a break or when a new pipe is added.

Empty the cuttings from the mud pit

Use a shovel to remove the cuttings from the mud pit.





Add a new drill pipe

- o First use the 1,5 meter weighted pipe and drill this into the ground.
- o Add a short drill pipe (75 cm).
- o When this is drilled you add another short pipe (75 cm).
- o Then add normal drill pipes of 1,5 meters length for the rest of the drilling.

Tip

In the first meters of drilling it is difficult to circulate the water (sludge). With the short drill pipes (75cm) it is easier to circulate. When you drill deeper, circulation with the normal pipes will become easier.

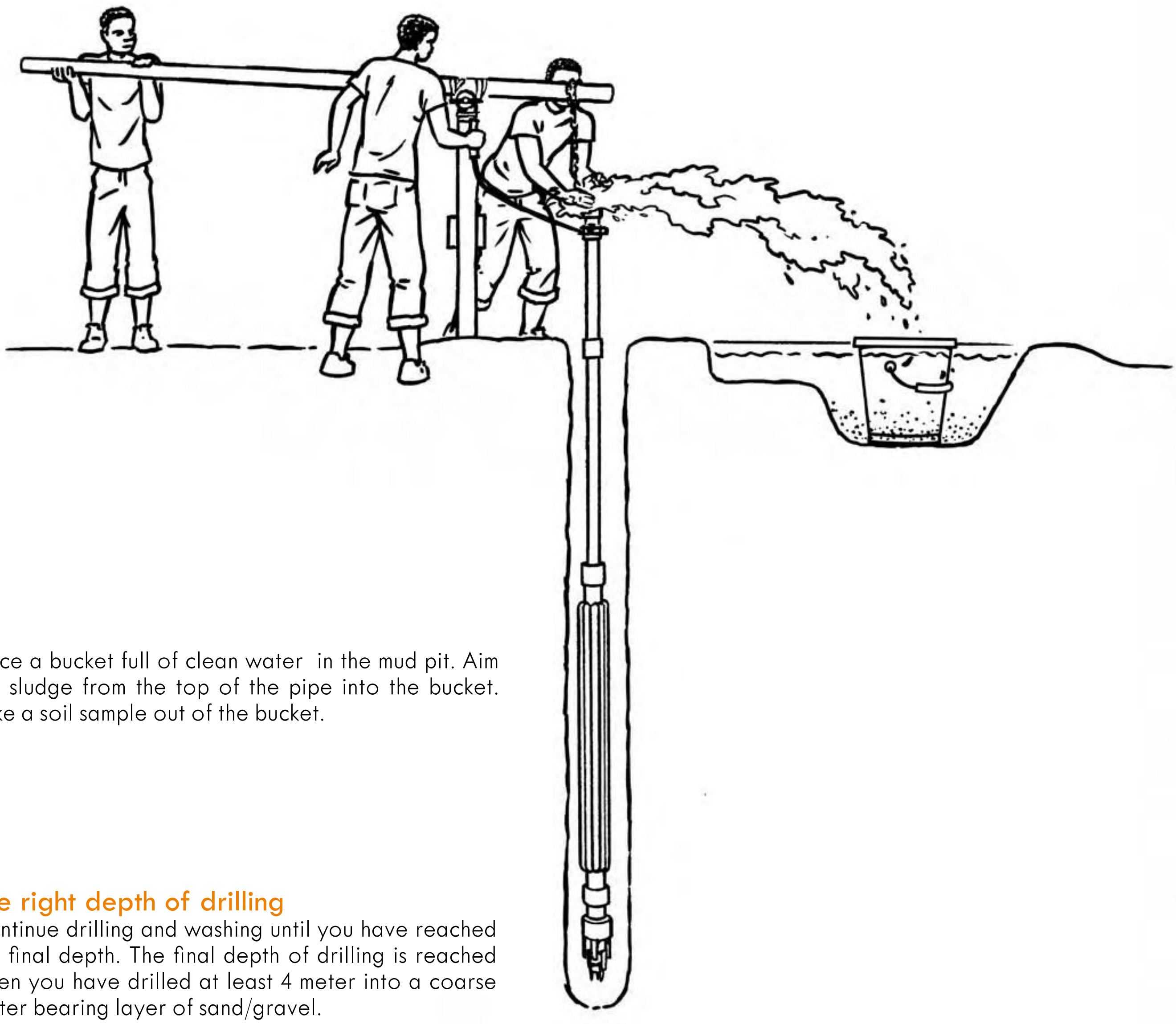
Tip

Drilling is a heavy task when you drill deeper. Let more team members join on the lever.

STEP 8 DRILLING TO THE RIGHT DEPTH

Take soil samples

Take a soil sample of the drilled soil, every meter or every time before a new pipe is added.



Place a bucket full of clean water in the mud pit. Aim the sludge from the top of the pipe into the bucket. Take a soil sample out of the bucket.

The right depth of drilling

Continue drilling and washing until you have reached the final depth. The final depth of drilling is reached when you have drilled at least 4 meter into a coarse water bearing layer of sand/gravel.

Tip

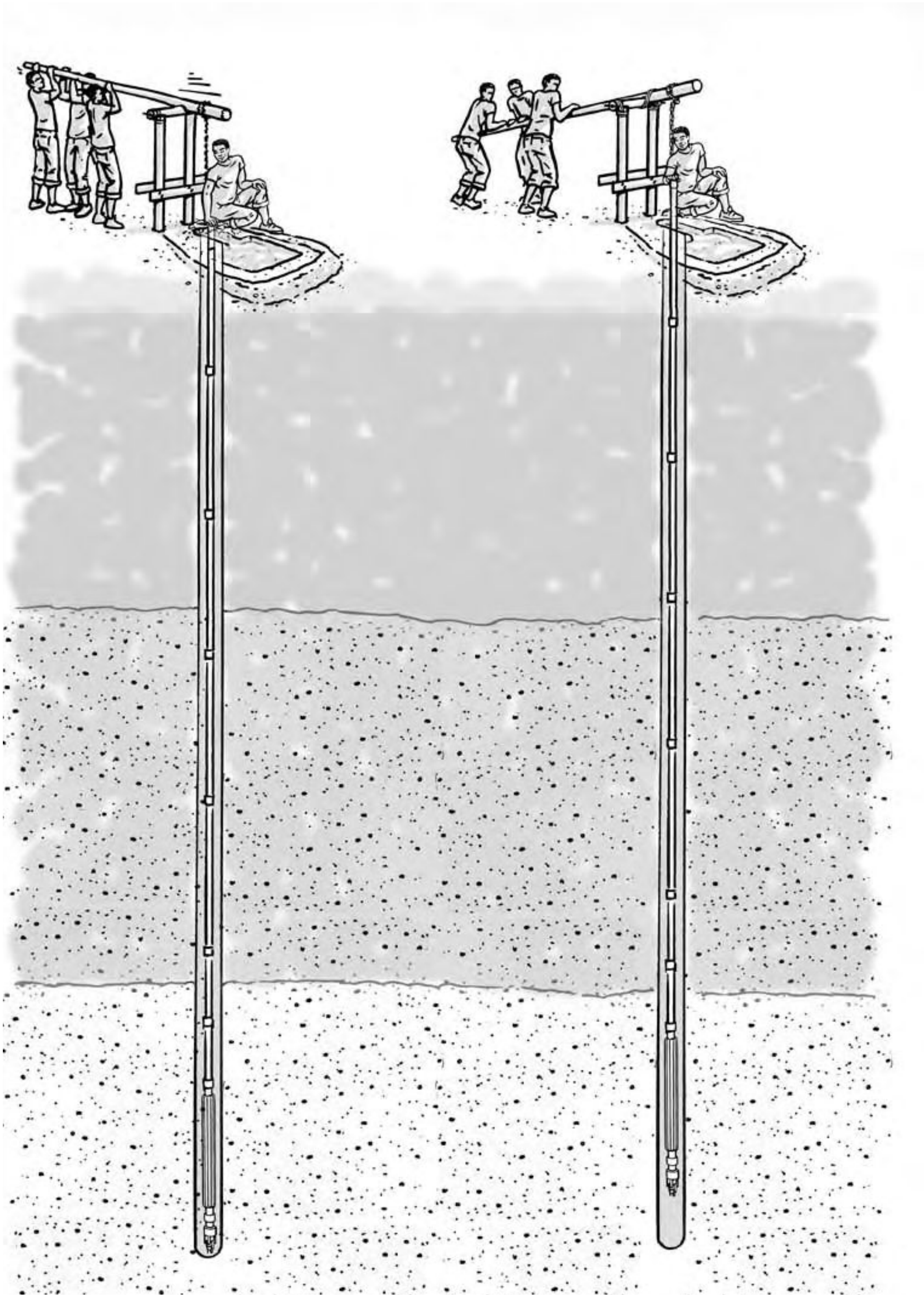
Place the samples on a piece of plastic and write down the depth.

STEP 9 THE FINAL STEPS

Only continue with the next steps if you have reached the final depth of drilling

Wash the borehole

Circulate (wash) the sludge continuously until ALL the cuttings are removed from the borehole (do not drill deeper!).

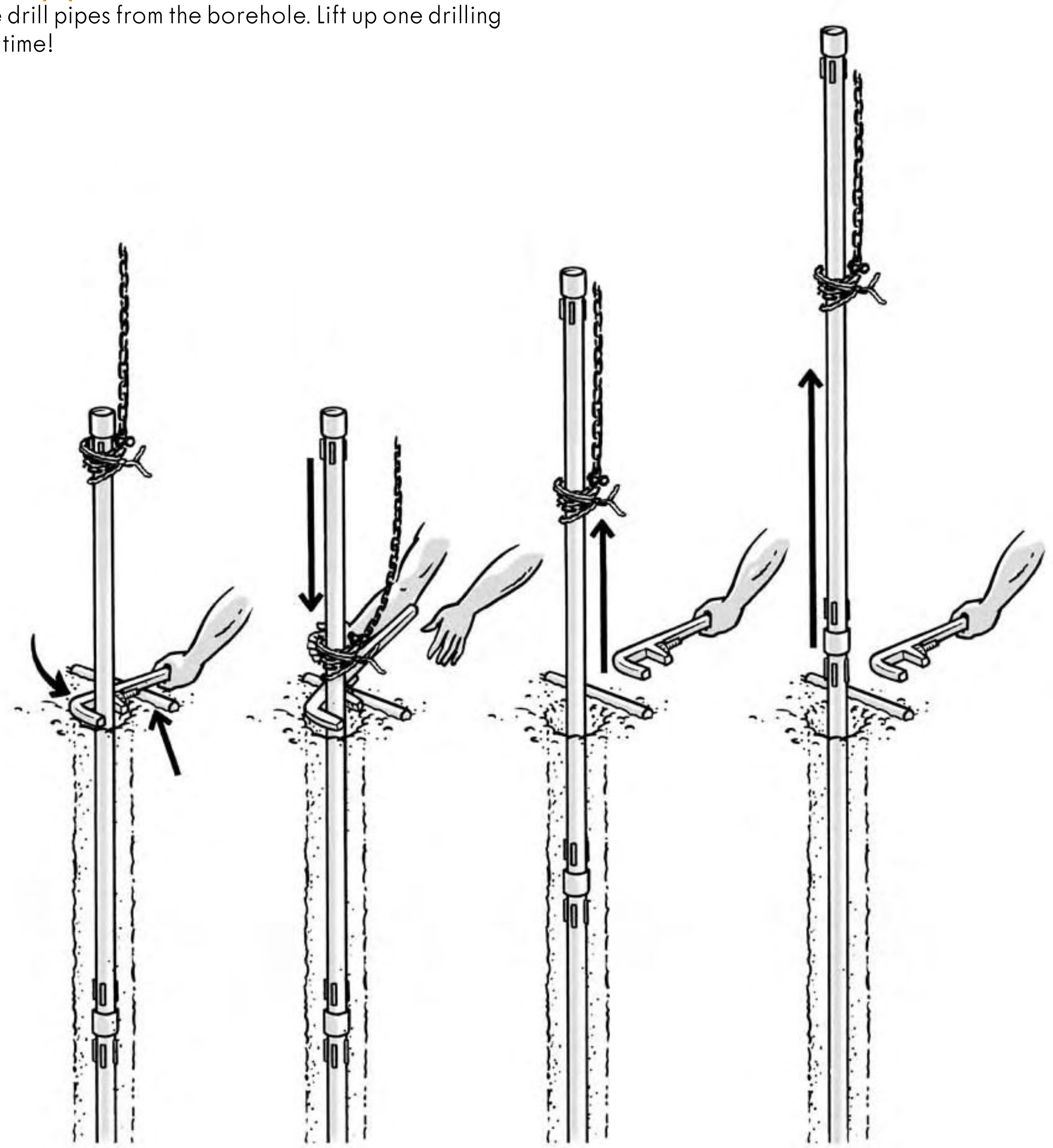


Tip

Washing is a heavy task. Let all the team members join on the lever during washing.

Lift the drill pipes

Remove the drill pipes from the borehole. Lift up one drilling pipe at the time!



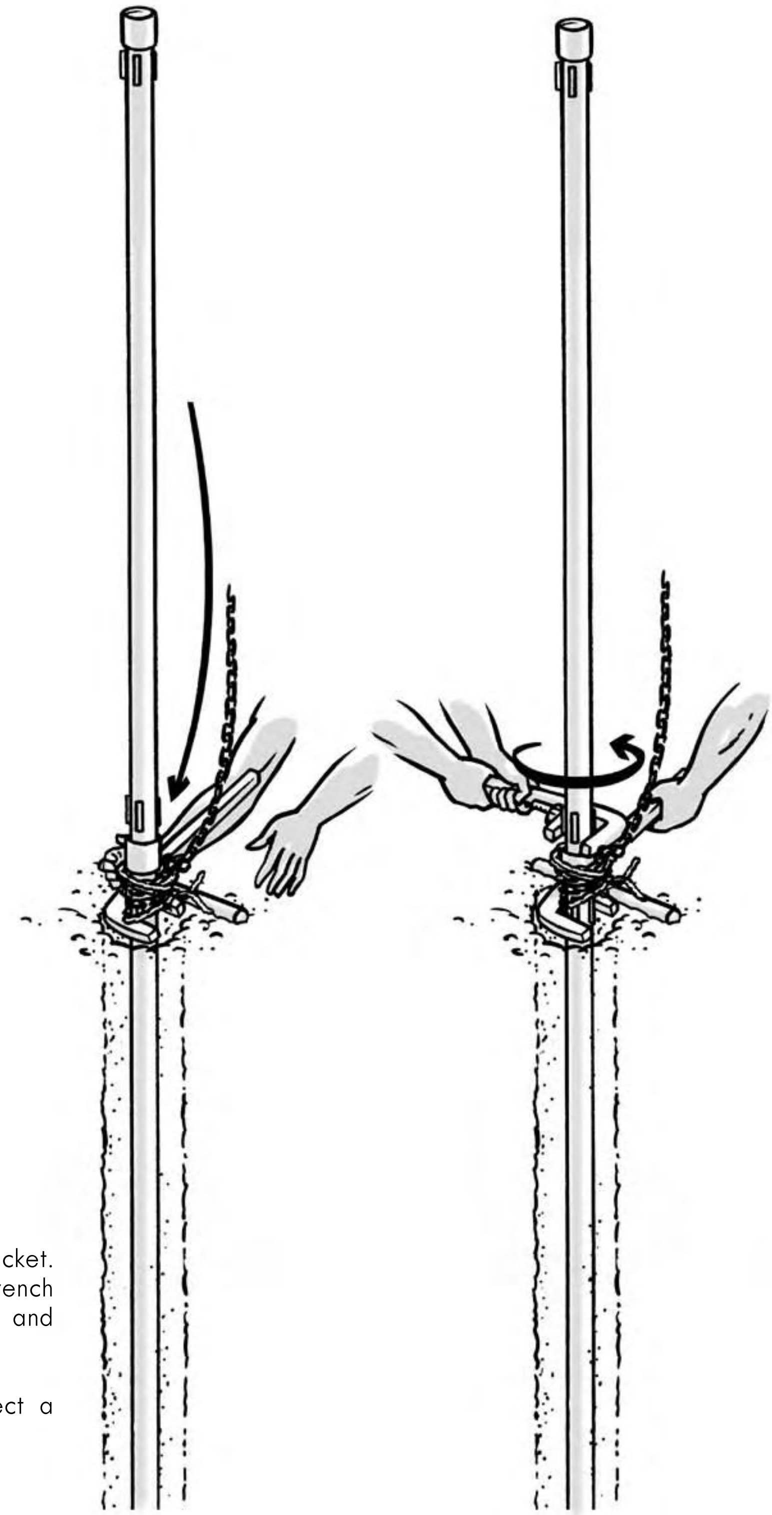
1. Lift up the drill pipe (with the lever) and place a pipe wrench around the drill pipe.
2. Lower the pipe until the pipe wrench holds the pipe. Move the lever up and slide down the chain along the drill pipe.
3. Lift up the drill pipe.
4. Repeat step 1-3 until the pipe wrench can be placed under a socket.

Tip

Make sure the jaws of the pipe wrench have a tight fit with the pipe to have good grip.

Tip

To prevent your pipe wrenches and spanners from falling into the borehole, secure them with a small rope to the frame poles



5. Place the pipe wrench under the socket. Lower the pipe until the pipe wrench holds the pipe. Remove the chain and place the chain under the socket.

6. Now it is now safe to disconnect a drilling pipe.

Be careful!

Pay close attention when you remove the drill pipes. All team members should be fully concentrated. If the drill pipe is not held properly by a pipe wrench or chain, the pipe can FALL BACK into the borehole.

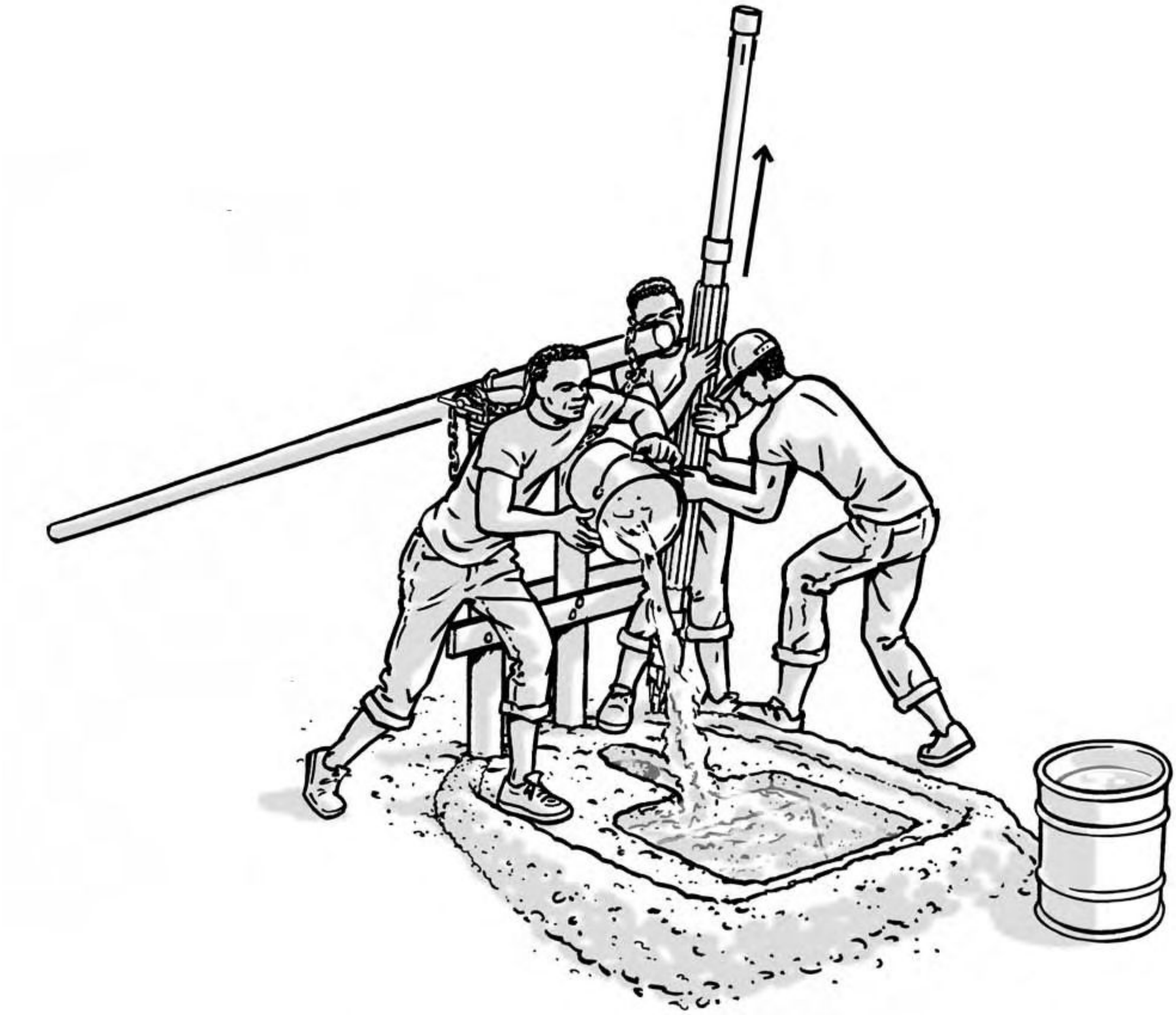
Pulling lost drill pipes from the bottom of your borehole will not be easy. Please see in chapter 5 of this module the paragraph: 'Fishing when a pipe has dropped.'

Tip

Always secure the drill pipe with the chain before you disconnect a pipe! Hold the lever as the pipe may slip out of the pipe wrench.

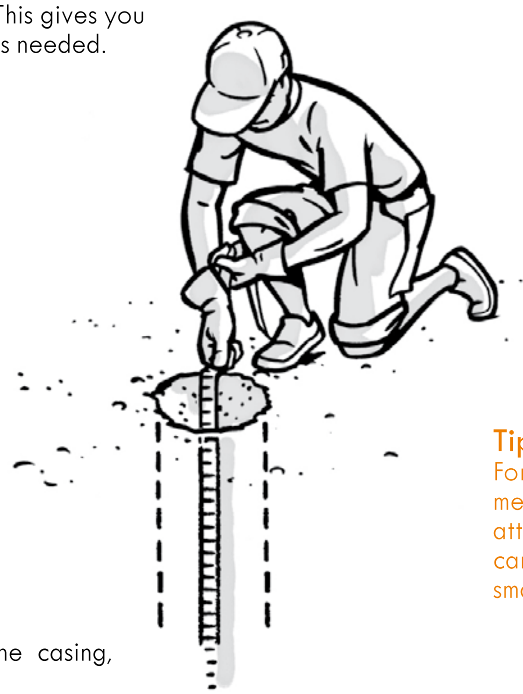
Keep the borehole full of water

Always keep the borehole and the mud pit full of water when you remove the drill pipes install the following well installation process, to prevent the well from collapsing.



Measuring the depth of drilling

Measure the exact depth of your borehole. This gives you information on the total length of casing pipes needed.



Tip!

For measuring; use a rope or long measuring tape with a small weight attached. Measuring with a rope can be best done when you make small knots at every meter.

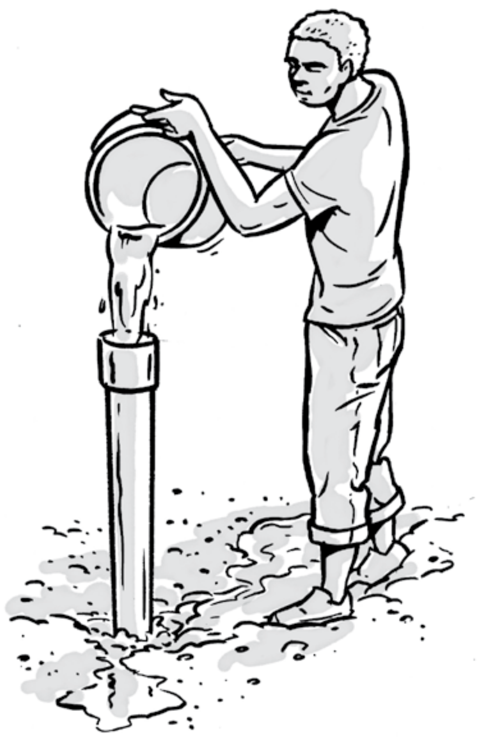
Installation of the PVC casing

Prepare the filter screen, the sump and the casing, before you start the installation (1).

Lower the filter screen into the borehole (2). Then screw or glue the first PVC casing pipe to the screen (3). Lower the casing further into the borehole (4). More PVC pipes are added one by one.

Tip!

Always make sure that one person is holding the casing to prevent it from dropping into the borehole.



Cleaning the well and the screen

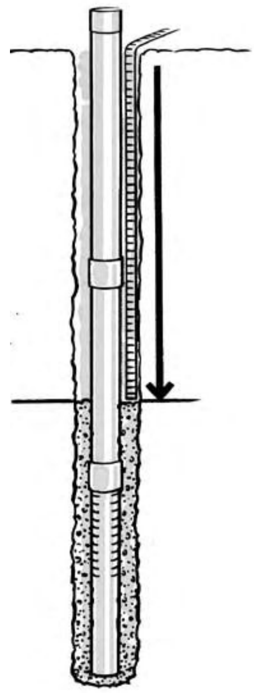
When the casing and screen is installed, the borehole and screen are now further cleaned:

Drain the dirty water away from the mud pits.

Then pour clean water into the casing and allow dirty water to overflow the borehole. Only when clean water comes out of the borehole, the cleaning is finished and the gravel packing can start.

Gravel packing

Start slowly pouring in the gravel, all around the pipe. While putting the gravel in, keep moving the PVC pipe from side to side in the borehole.



Measuring the depth of the gravel pack

Measure regularly to check if the right depth of gravel packing has been reached. Fill the open space between the casing pipe and the borehole wall for 1-2 m above the top of the filter screen.

Backfilling

After you have installed the gravel pack, you must install the sanitary seal and the rest of the backfilling.

Leaving the well behind

When the drilling is finished and you are leaving the site, remember to cover the PVC casing!

This can be done with a PVC cap or tightly wrapped with inner tube. This is needed to ensure that nothing can be dropped into the well by children, before the pump is installed.

5. SPECIFIC SITUATIONS AND COMMON PITFALLS

Drilling in compacted soils

In hard and compact formations such as, stiff clay, tuff stone and sandstone, it is useful to connect a second weighted pipe to the first weighted pipe. This will give more pressure on the teeth of the drill bit and will make the drilling more effective. If this doesn't work, first drill a hole with a smaller drill bit. Then use the normal drill bit to make your borehole wider. Do not use a second weight in very soft soils such as loose sands and soft clay. This will make the drilling going too fast, with the risk that you block your pipes easily.

Bouncing pipe

When your drill pipe starts to 'bounce' (jump) you have hit a hard consolidated formations, stone or a big boulder that is difficult or impossible to drill. You can recognize this by a change in sound (higher 'ping' sound) and less resistance during the rotation of the arm.

Check if there is drilling material coming to the surface. If this is not the case, just keep drilling for a while and check the progress. If drilling deeper is not possible, it is better to move to another drilling site. Only install a casing if you have drilled enough meters into a good aquifer.

Blocked pipe

Sometimes it is impossible to circulate the sludge. When you are inexperienced you can face problems with keeping the vacuum on the drilling pipe with your hand. Practice more to overcome this problem. When you lost your vacuum, you can add water in the top of the pipe and try again.

There could also be a leakage in the drill pipe. You can hear this when you lift the pipe, while the top of the pipe is closed. Repair the pipe in a workshop and try again.

The drill pipes or bit can also be blocked with cuttings. In this case there are 2 things you can do;

1. Lift up the drill pipe one meter or more and try to wash again using large strokes on the lever.
2. Remove all pipes from the borehole and remove the cuttings that have caused the blockage. Slowly lower the pipes again in the borehole and start to wash until the borehole is clean.

What if your pipe is stuck

If you forget to wash before taking a break or when a stone from the borehole wall falls down, the cuttings or stone will fall on top of the drill bit. The drill bit will get stuck. In this case, DO NOT put a lot of pressure on the lever, but try to make very short strokes and rotate clockwise to loosen the material. If you are successful you will notice that bit by bit the strokes become longer. Continue until the pipe is loose and start washing.

Drilling deeper

The chain can be attached at different positions on the lever. The closer the distance from chain to the frame, the lighter it is to move the drill pipes up and down, but the stroke of the drill pipes will become shorter, so only do this when you drill deeper.
Normally the chain is attached 40 cm from the frame. When you drill deeper, the lever is easier to operate when you move the chain to 30 cm from the frame. This way, the lever has more strength for lifting the drill pipe and minimizes the chance of breaking.

The lever

The lever is made out of a dry and light weight piece of round wood (preferably eucalyptus) with a length of about 2,5 meters. The diameter varies from 7-10 centimeters at holding position and slightly bigger at the end of the frame. To avoid blisters and cuts, remove all sharp wood chips before you start using it.

Fishing when a pipe has dropped

When a pipe has fallen back into the borehole by accident, it needs to be recovered quickly. There are 2 things you can do;

1. Lower your drill pipe slowly back into the borehole and try to find the top of the lost pipe. Carefully try to screw your drilling pipe onto the lost pipe. Then slowly lift the pipes again.
2. When a pipe is broken during drilling: lower your drill pipe to find the top of the broken pipe. Make a lasso out of the chain and guide it down along the drill pipe. When the lasso has passed the broken pipe, you pull the chain tight behind a socket and try to lift the pipes with the chain (attach a strong rope to the chain to go deeper).

Never forget!!

1. Keep your borehole full of water at all times.
2. Always choose a site at least 30 m away from a latrine and other sources of pollution.
3. If you pause drilling for a longer time (for example lunch), wash the well and lift up the pipes for 2 meters. This will prevent the drilling pipe from getting stuck.
4. Always take soil samples. Place them on a plastic sheet and write down the depth. This will help to determine the depth of your drilling.
5. Always place your filter screen in the coarsest layer of sand or gravel under the water table.
6. Use a sump (blind pipe) below your filter screen to collect any fine material that enters the well.
7. A guideline for the length of the filter screen is 3 meter.
8. When the drilling is finished and you are leaving the site, remember to cover the PVC casing. This can be done with a PVC cap or a plastic bag tightly wrapped with inner tube. It is needed to ensure that nothing can be dropped into the well by children.

Tool maintenance

- Look after your drilling pipes. Keep threads clean and apply some grease to the threads. Protect threads with a PVC cap, socket or wrapping, especially during transport, to prevent damage.
- Regularly sharpen the teeth of the drilling bit using an angle grinder.
- Check the welds on the drilling pipes, arm and drilling bit.
- Regularly check the drilling pipes for straightness and leakages.
- Check if the tools are complete and replace if necessary.
- Inspect the chain and ropes and replace when needed.

SLUDGING

Module 3

MAKING THE DRILLING EQUIPMENT

PRACTICA FOUNDATION

IDE

ETC

1. WHAT TO BUY

This module explains how to fabricate all drilling equipment. It consists of a materials list for the drilling equipment and tools and a package of technical drawings, including tips that are necessary to make a complete drilling set.

Material list for the construction of drilling equipment

"ROTA SLUDGE" KIT - 30 meters					
Nr	**EQUIPMENT**	**Part**	**Dimensions**	**Material + Information**	**Qty**
1	**Drill bit**	**3000**	**D = 15 cm**		**2**
	Central pipe	3001	2" x 3,9 wall x 250mm	GI pipe	2
	Upper ring	3002	Ø 120 x 10 x 50mm	Fe36 pipe	2
	Lower ring	3003	Ø 95 x 10 x 50mm	Fe36 pipe	2
	Ring support	3004	25 x 25 x 3 x 50mm	Fe36 angle iron	8
	Upper welding support	3005	Ø 8 x 320mm	Reinforcement bar	2
	Lower welding support	3006	Ø 8 x 200mm	Reinforcement bar	2
	Tooth short	3007	18 x 10 x 75mm	Leaf spring	16
	Tooth long	3008	18 x 10 x 90mm	Leaf spring	8
	Coupling		2"	GI	2
2	**Weighted drilling pipe**	**2100**	**L = 150 cm**		**2**
	Weight	2101	Ø 14 x 1300mm	Rebar	32
	Drill pipe normal	2200	2" x 3,9 wall x 1400mm	GI	2
	Threaded pipe	2001	2" x 5,5 wall x 100mm	GI pipe	2
	Rib	2003	Ø6 x 50mm	Rebar	16
	Coupling		2"	GI	2
3	**Normal drilling pipe**	**2200**	**L = 150 cm**		**18**
	Drill pipe normal	2200	2" x 3,9 wall x 1400mm	GI	18
	Threaded pipe	2001	2" x 5,5 wall x 100mm	GI pipe	18
	Rib	2003	Ø6 x 50mm	Rebar	144
	Coupling		2"	GI	18
4	**Short drilling pipe**		**L = 75 cm**		**2**
	Drill pipe short	2300	2" x 3,9 wall x 650mm	GI	2
	Threaded pipe	2001	2" x 5,5 wall x 100mm	GI pipe	2
	Rib	2003	Ø 6 x 50mm	Rebar	16
	Coupling		2"	GI	2
5	**Rotation arm**	**1000**			**1**
	Lock ring	1001	Ø 6 x 105mm	Round bar	4
	Hub	1101	1"x 3,4 wall x 75mm	GI pipe	1
	Midpiece	1102	1" x 3,4 wall x 150mm	GI pipe	1
	Reinforcement strip	1103	30 x 4 x 250mm	Fe36 strip	1
	Clamp strips	1201, 1202	80 x 5 x 140mm	Fe36 strip	2
	Chain link	1203	Ø 6-7 x max. 40mm	Iron	6
	Reinforcement	1205	Ø 8 x 80mm	Round bar	8
	Grip ridge	1206	Ø 8 x 80mm	Round bar	8
	Axle	1301	Ø 25 x 160mm	Round bar	1
	Connecting pipe	1302	1" x 3,4 wall x 200mm	GI pipe	1
	Handle	1303	3/4" x 2,9 wall x 1000mm	GI pipe	1
	Grip	1304	1" x 3,4 wall x 200mm	GI pipe	1
	Reinforcement strip	1305	30 x 4 x 250mm	Fe36 strip	1
	Bolt wing	1401	Ø 10 x 130mm	Round bar	1
6	**Axle**	**4000**			**1**
	Half bush	4001	80 x 5 x 70mm	Fe36 strip	1
	Axle	4101	Ø 30 x 500mm	Round bar	1
	Axle end stop	4102	Ø 10 x 200mm	Round bar	2

Purchase list for additional tools

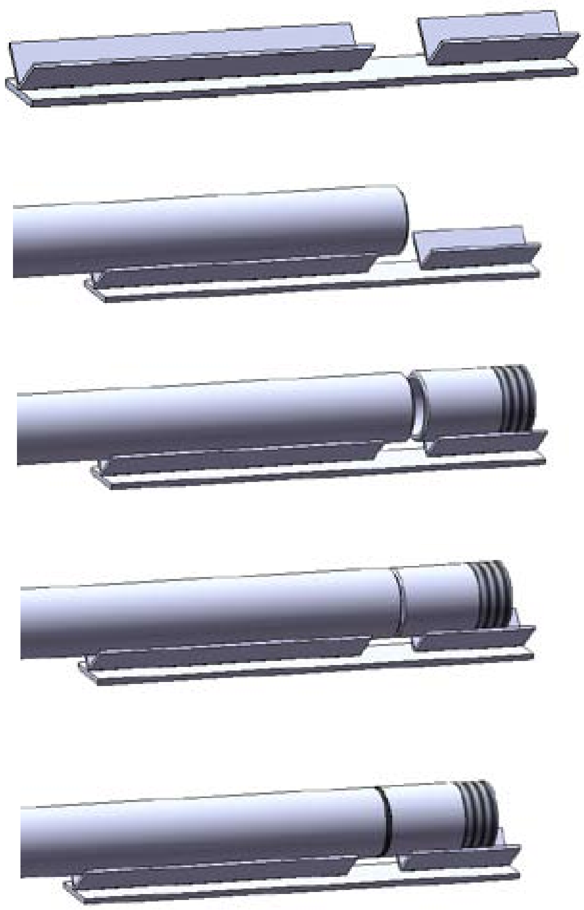
Nr	TOOLS & MATERIALS	Dimensions	Additional information	Qty
	Set up rota-sludge			
7	Frame pole	10-14 cm X 240 cm	wood (round or square)	2
8	Support planks	10 x 80 cm	wood	2
9	Lever	7-8 cm x 250 cm	dry wood (round & straight eucalyptus)	2
10	Chain	6 x 30 x 150 cm	steel	1
11	Bolt + nut	8 x 60 cm	steel	4
12	Nails	10 cm	steel	10
13	Rope	Ø 15 mm (4 meters)	organic	1
	Tools			
14	Conical auger	Ø 160 mm	Minimum length of 150 cm	
15	Sieves	mesh 1,5 & 3,0 mm	holes can also be punched in sheet metal using nails	2
16	PVC glue			1
17	Pipe wrenches	24 inch	good quality	3
18	Toolbox (full)		hammer, spanners (M8), steel brush, scissors	1
19	Empty oil drums	200 liters	steel (plastic drums can also be used)	3
20	Hack saw		assure spare blades	2
21	Buckets	12 liters	plastic	3
22	Shovel		steel	1
23	Crowbar	150 cm		1
24	Rope	Ø 6 mm (35 meters)	organic	1
25	Strip	150 cm	rubber (innertube)	1
26	Depth measuring tool			1
	Materials			
27	PVC casing pipe		size depends on pump/user requirements	1
28	Additives		1 bag	1
29	Gravel pack		1 and 3 mm	1

2. TIPS FOR CONSTRUCTION

Read the following tips together with the technical drawings at the end of this module. These tips will help you in the fabrication of the drilling pipes, drill bit and the measuring tool. The other drilling equipment can be made with the technical drawings only.

TIPS FOR MAKING THE DRILLING PIPES

(To be used by construction of drawing nr: 2000 – 2301)



Normal drilling pipes

Thin wall drilling pipes are cheap and great in use, but when intensively used they break at the threaded connections! To overcome this problem:

a) Screw a regular steel coupling on the one side of the thin wall pipe and weld it.

b) Weld a short piece of thicker wall pipe with threads to the other side of the thin wall pipe.

How to weld the coupling

The thin wall pipe needs to be threaded on one side. Then, screw the steel coupling completely on this thread and weld the coupling to the thin wall pipe.

How to weld the thick wall pipe

Take a short piece of thick wall pipe and make threads on one side. Now weld the opposite side to the thin wall pipe. Be careful: It is very important that they are centered properly!

Tip

A good tool to make is a mould (welding jig) as shown in the picture. The mould consists of two pieces of angle iron welded inline on a solid base (1). The thin wall pipe (2) and the short piece thick wall pipe can now be placed in the mould (3). Shift the two pipes to each other (4). Then weld the two pieces together, all around (5). This will assure a straight connection.

Tip:

Make sure the threads are greased to protect the threads during welding (welding sparks).

Weighted pipes

First make a normal drilling pipe as described above; weld a coupling on one side and short piece of thick wall pipe on the other side.

Then, weld pieces of re-bar around the normal drilling pipe, to increase the weight of the pipe. Make welds at the bottom, middle and top as shown in the picture. Two sizes of re-bar can be used;

1) 14 mm re-bar of 1,3 meters. Use 16 pieces.

2) 16 mm re-bar of 1,3 meters. Use 14 pieces.

Tip

Be careful when welding the re-bar, NOT to burn holes in the normal drilling pipe! This will give problems with the circulation (you will loose your vacuum) during drilling.

TIPS FOR MAKING THE DRILL BIT

(To be used by construction of drawing nr: 3000 – 3008)

The drill bit

There are 2 important tips for construction.

1) Make the drill teeth out of spring leaf steel (use spring leaves of trucks). This is hard steel and will last longer than ordinary steel. Use stainless steel electrodes to weld the teeth on the rings.

2) Weld the teeth on the smallest ring (the pipe) to point slightly inwards; the inner diameter of the teeth must be equal to the inner diameter of the pipe. In this way, drilled material can always pass through the pipe.

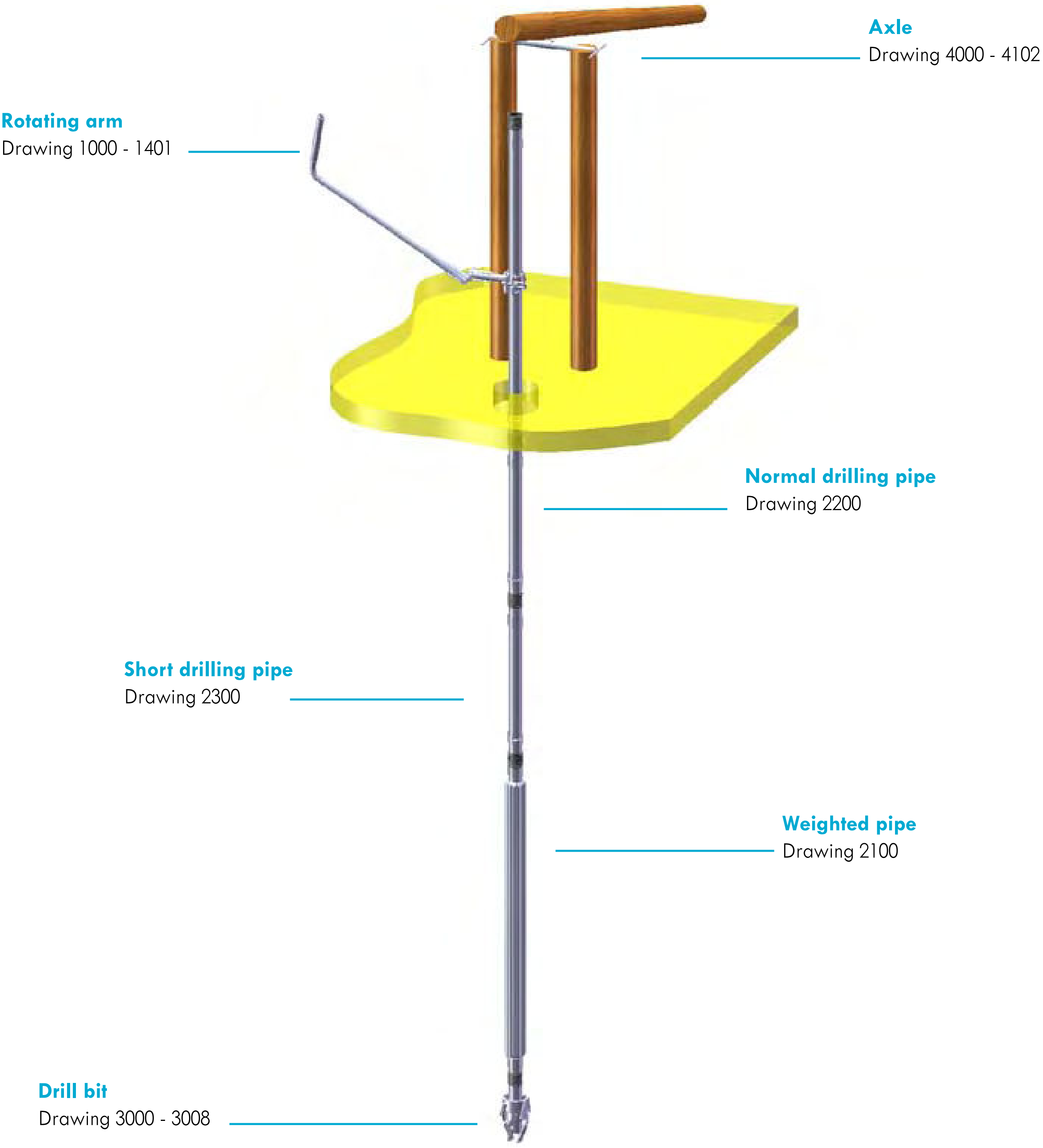
TIPS FOR MAKING THE DEPTH MEASURING TOOL

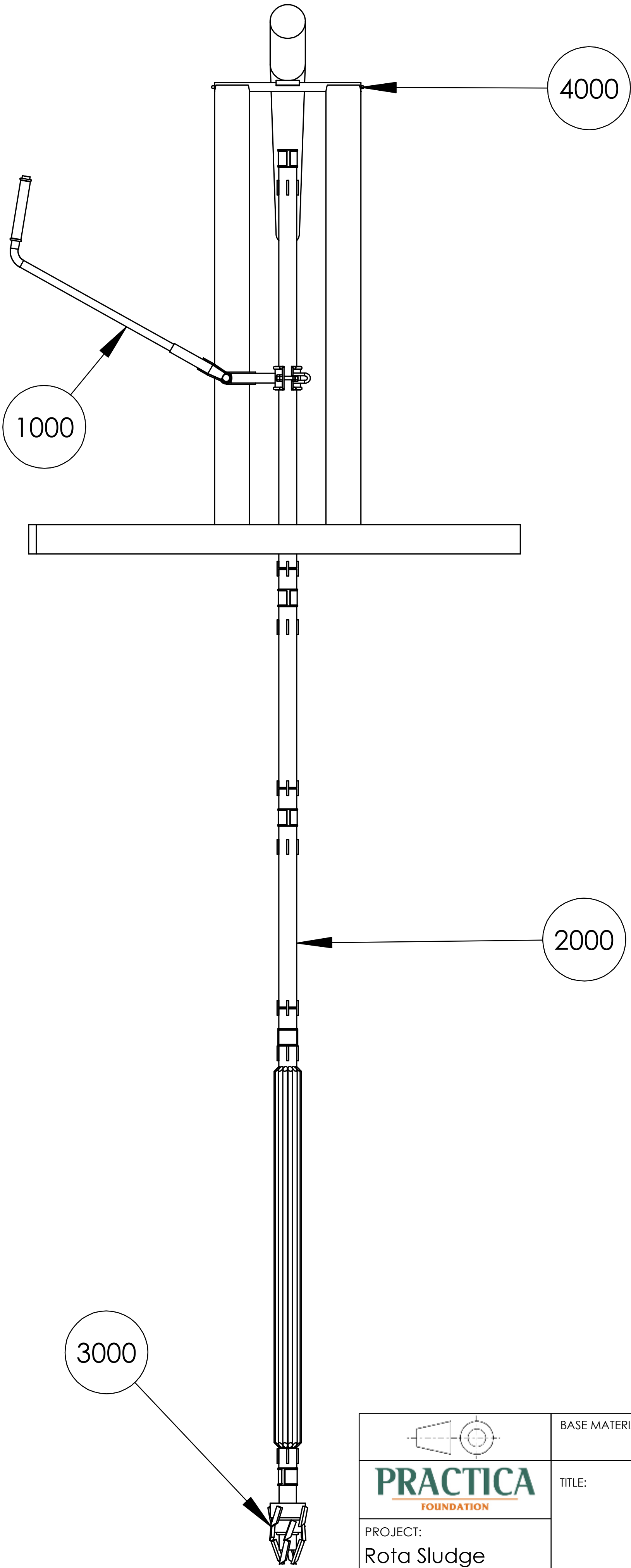
Take a rope (6mm) of about 35 meters long and make knots at every meter.

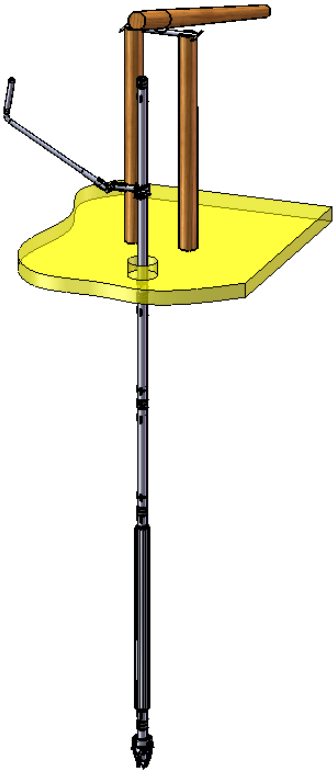
Option 1: measuring the depth of the water table. Use a short piece of pipe (Ø 50 x 80 mm) and close one side, by welding on a small plate. Drill a hole in this side to attach the rope.

Option 2: measuring the depth of the gravel pack. Take the same rope, and remove the short piece of pipe that was used in option 1. Attach a long re-bar (Ø 6 x 1000 mm).

3. TECHNICAL DRAWINGS







NO.	DESCRIPTION	QTY.
1000	Arm	1
2000	Drill pipe	1
3000	Drill bit	1
4000	Axle	1

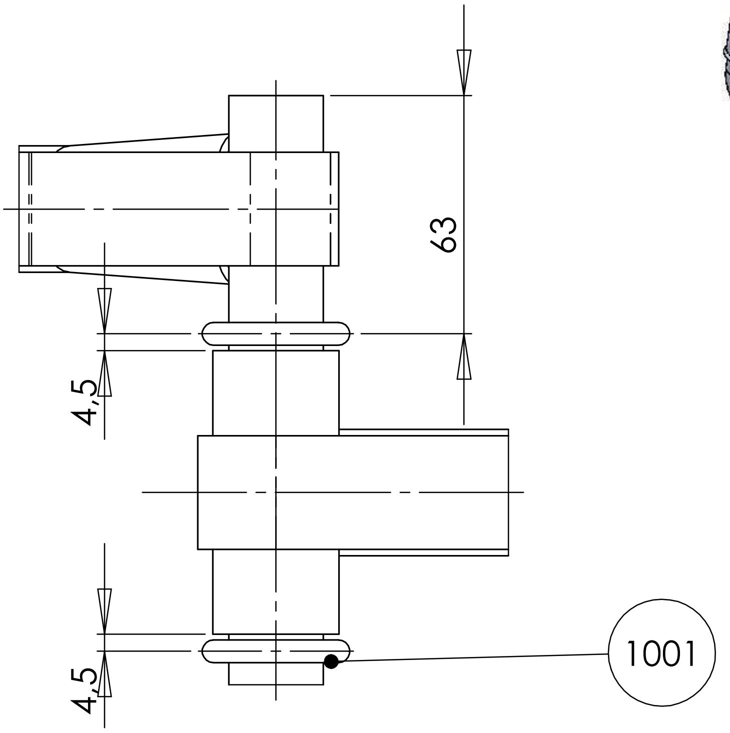
PRACTICA FOUNDATION

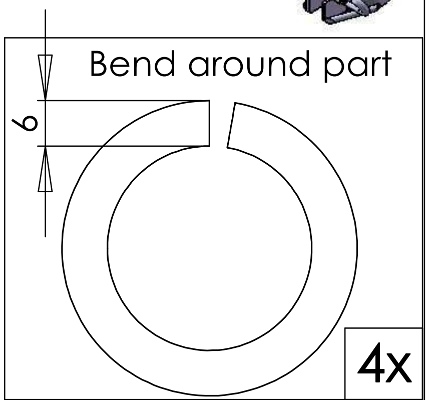
BASE MATERIAL: Part specific

TITLE: Rota Sludge

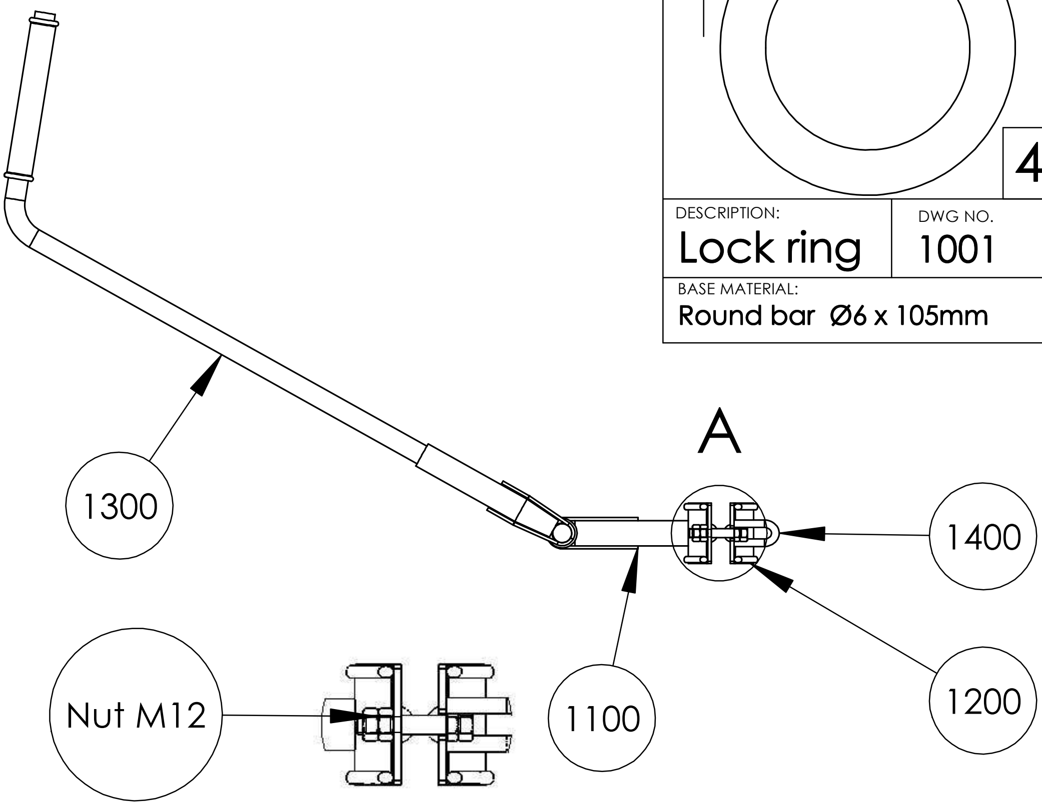
PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	0000	1:20	A4	2





DESCRIPTION:	DWG NO.
Lock ring	1001
BASE MATERIAL: Round bar Ø6 x 105mm	



DETAIL A
SCALE 1 : 5

NO.	DESCRIPTION	QTY.
	Nut M12	2
1001	Lock ring	2
1100	Hinge	1
1200	Clamp	1
1300	Arm	1
1400	Clamp bolt	1

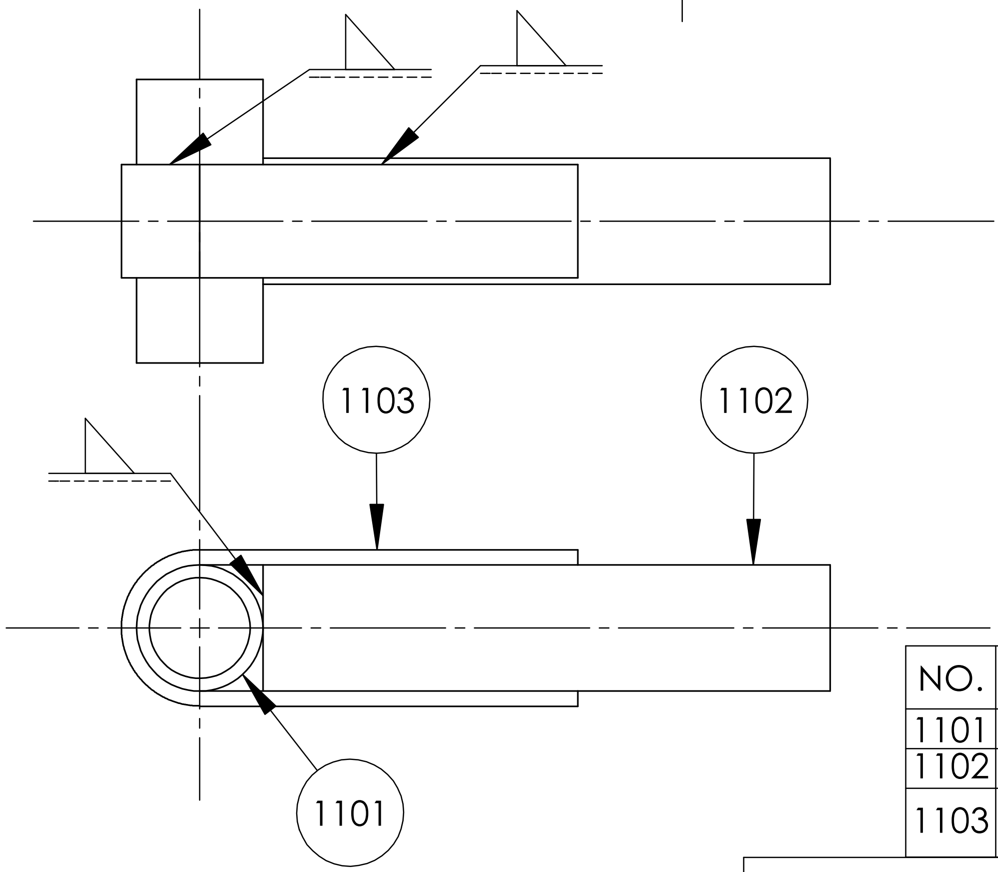
PRACTICA FOUNDATION

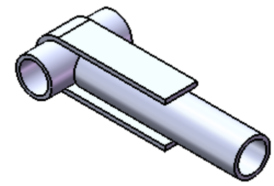
BASE MATERIAL: Part specific

TITLE: Rotation arm

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	1000	1:10	A4	3





1x

NO.	DESCRIPTION	QTY.
1101	Hub	1
1102	Midpiece	1
1103	Reinforcement strip	1

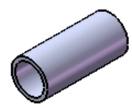
TITLE: **Hinge**

BASE MATERIAL: Part specific

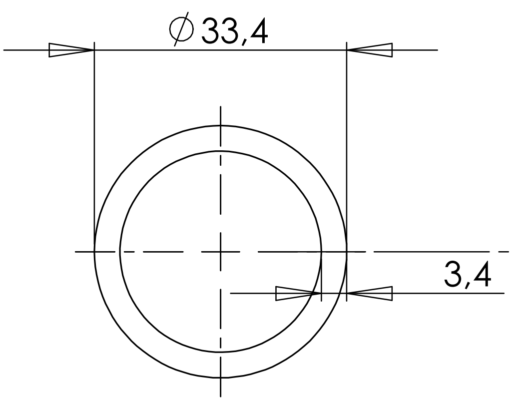
DWG NO. 1100

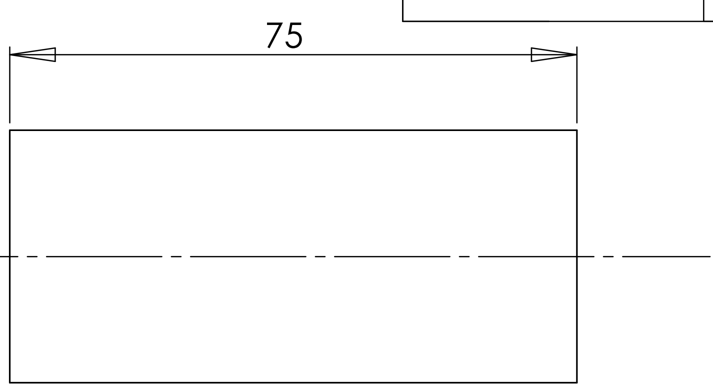
SCALE: 1:2

Pipe size is indicative.
Needs to fit over axle (dwg no. 1301).



1x





PRACTICA FOUNDATION

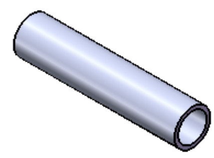
BASE MATERIAL: GI pipe NPS 1" 75mm

TITLE: **Hub**

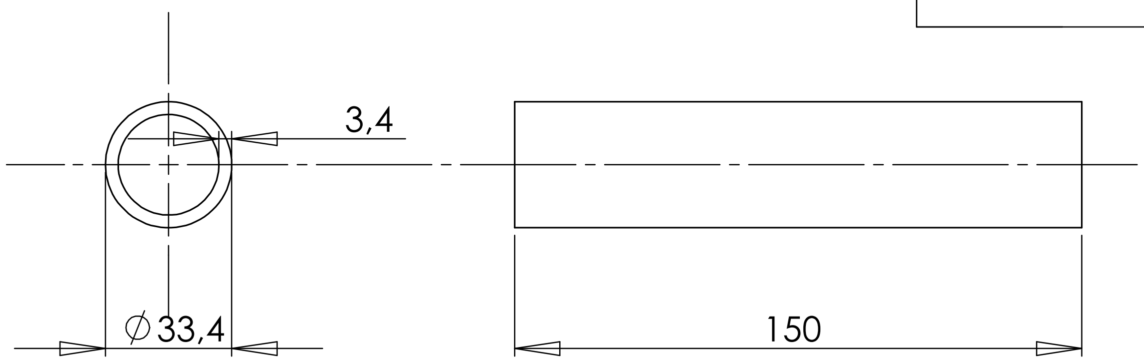
PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	1101	1:1	A4	4

1	2	3	4



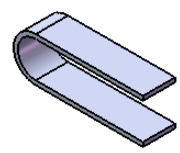
1x



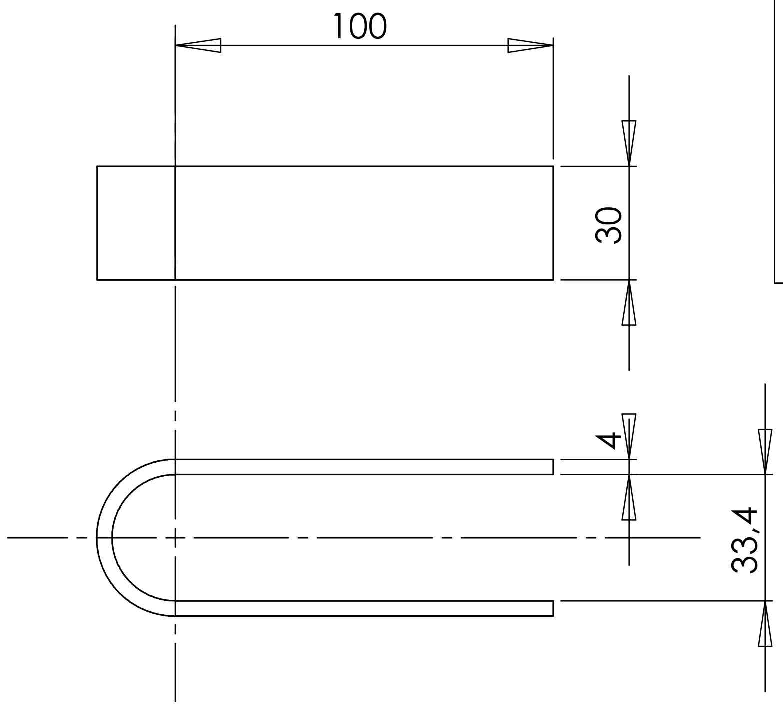
Diameters are indicative.
Choose same pipe as hub (dwg 1101).

TITLE: **Midpiece**

BASE MATERIAL: GI pipe NPS 1" 150mm	DWG NO. 1102	SCALE: 1:2



1x



Dimensions are indicative.
Bend around midpiece
and hub, and weld.

PRACTICA FOUNDATION

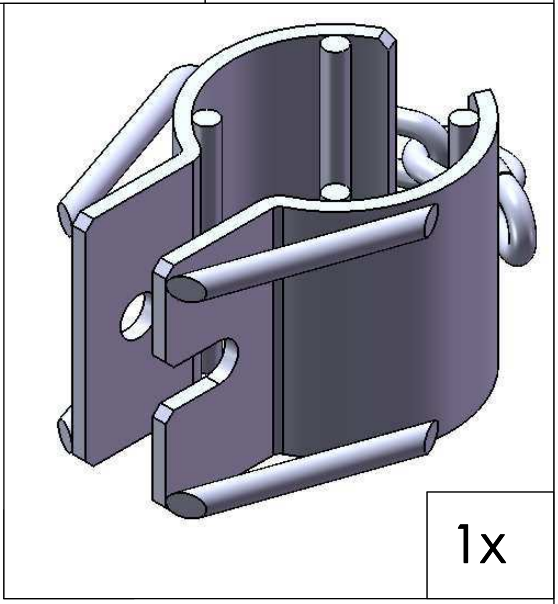
PROJECT: Rota Sludge

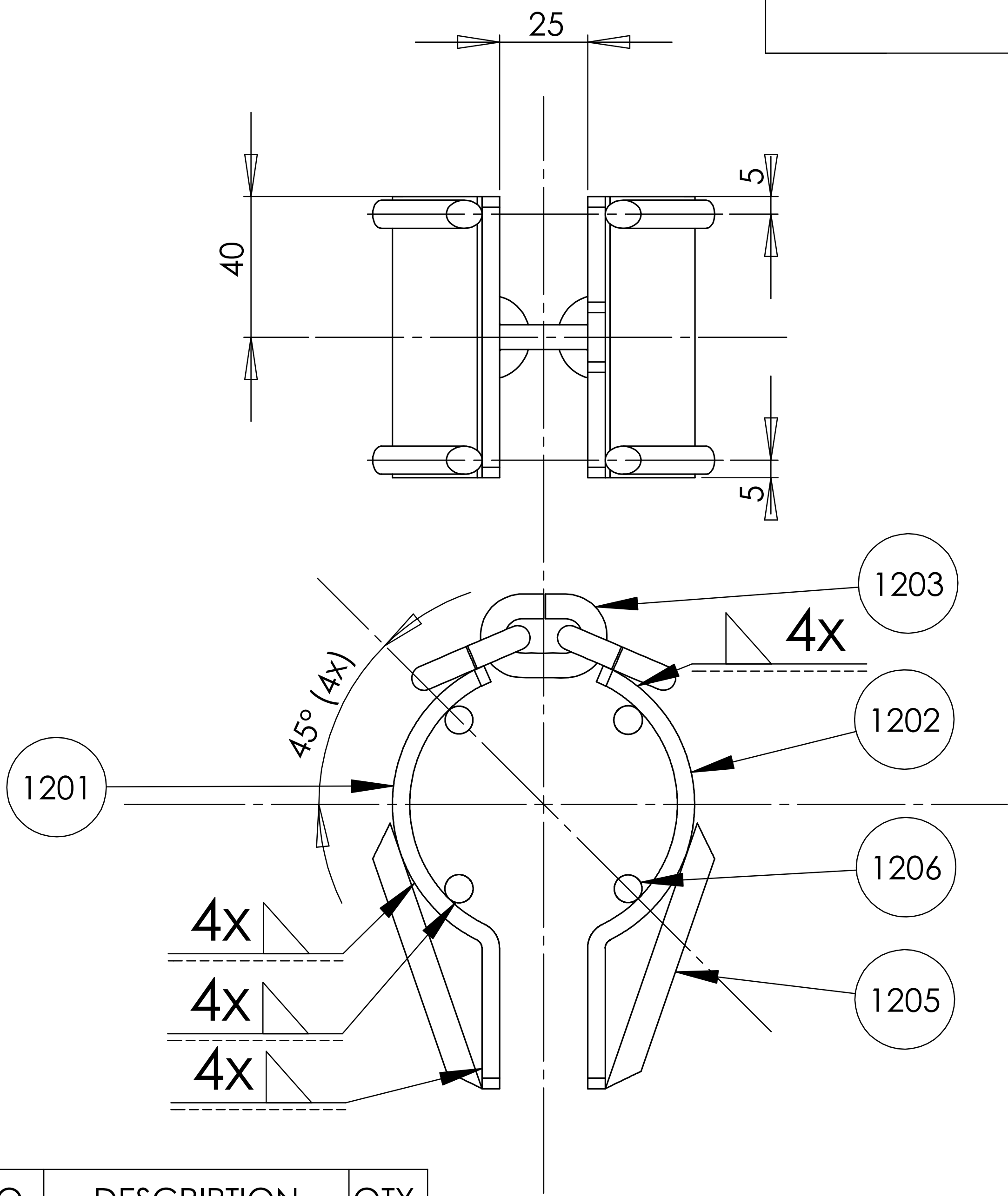
BASE MATERIAL: Fe36 strip 30 x 4 x 250mm

TITLE: **Reinforcement strip**

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	1103	1:2	A4	5

1	2	3	4





NO.	DESCRIPTION	QTY.
1201	Clamp strip	1
1202	Clamp strip (open ended)	1
1203	Chain link	3
1205	Reinforcement	4
1206	Grip ridge	4

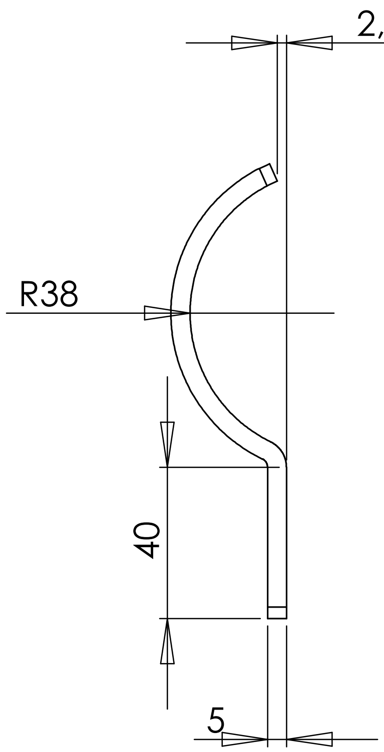
PRACTICA FOUNDATION

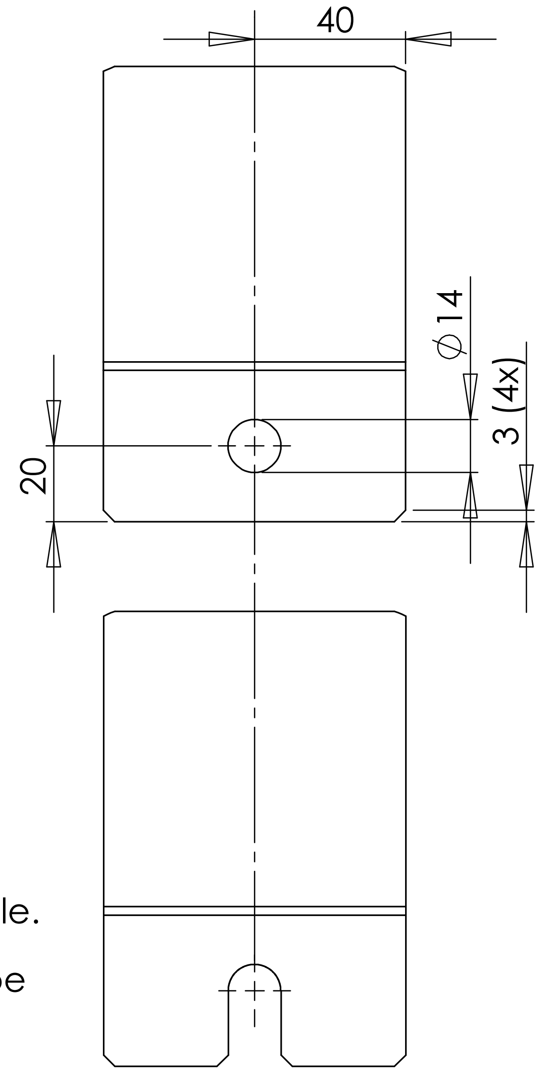
BASE MATERIAL: Part specific

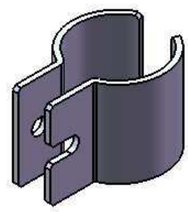
TITLE: Clamp

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	1200	1:2	A4	6







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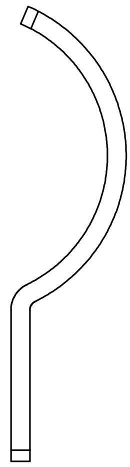
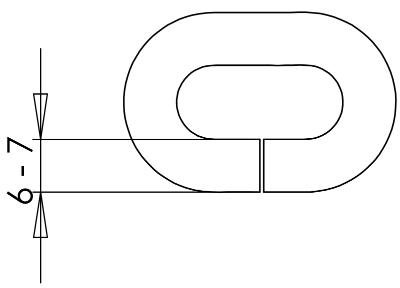
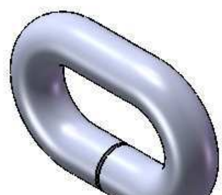


Strips are equal,
except for cut out hole.

Bend strip around pipe
or in vice grip.

TITLE:	Clamp strip
BASE MATERIAL: Fe36 strip 80 x 5 x 140mm	DWG NO. 1201, 1202 / SCALE: 1:2





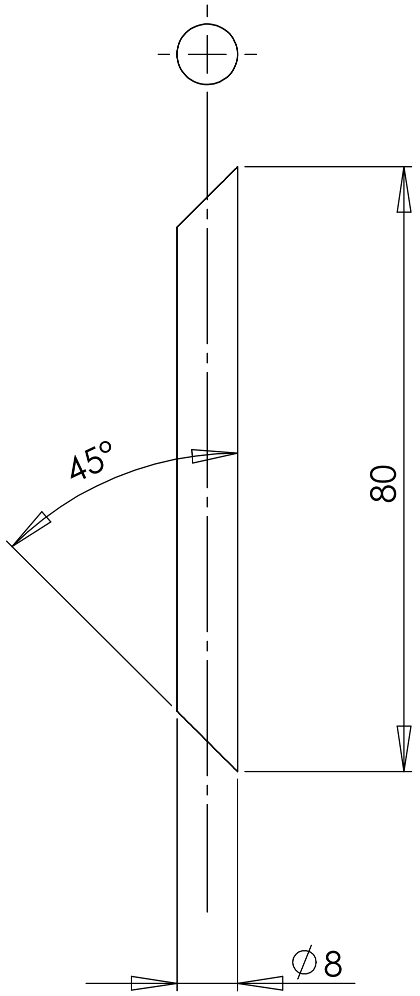
3x

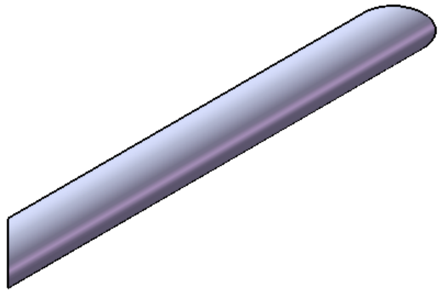
Choose available
chain type, for
example:

DIN766 7mm, or
British Mild Steel
Link Chain 1/4"

Link thickness should be
between 6 and 7mm.
Width should not exceed
40mm.

PRACTICA FOUNDATION	BASE MATERIAL: Iron				
PROJECT: Rota Sludge	TITLE: Chain link				
DRAWN BY: Erik den Toom	DATE: 18-2-2011	VERSION: Practica model - v1.0	DWG NO. 1203	SCALE: 1:1	FORMAT: A4 / PAGE NO. 7





4x

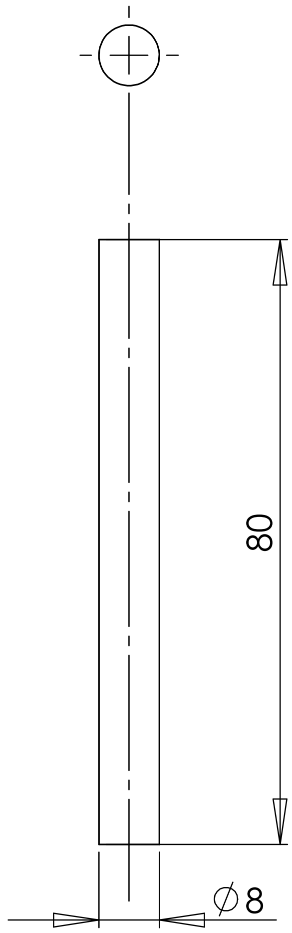
Grind down edges after welding.

TITLE: Reinforcement

BASE MATERIAL: Round bar Ø8 x 80mm

DWG NO. 1205

SCALE: 1:1



4x

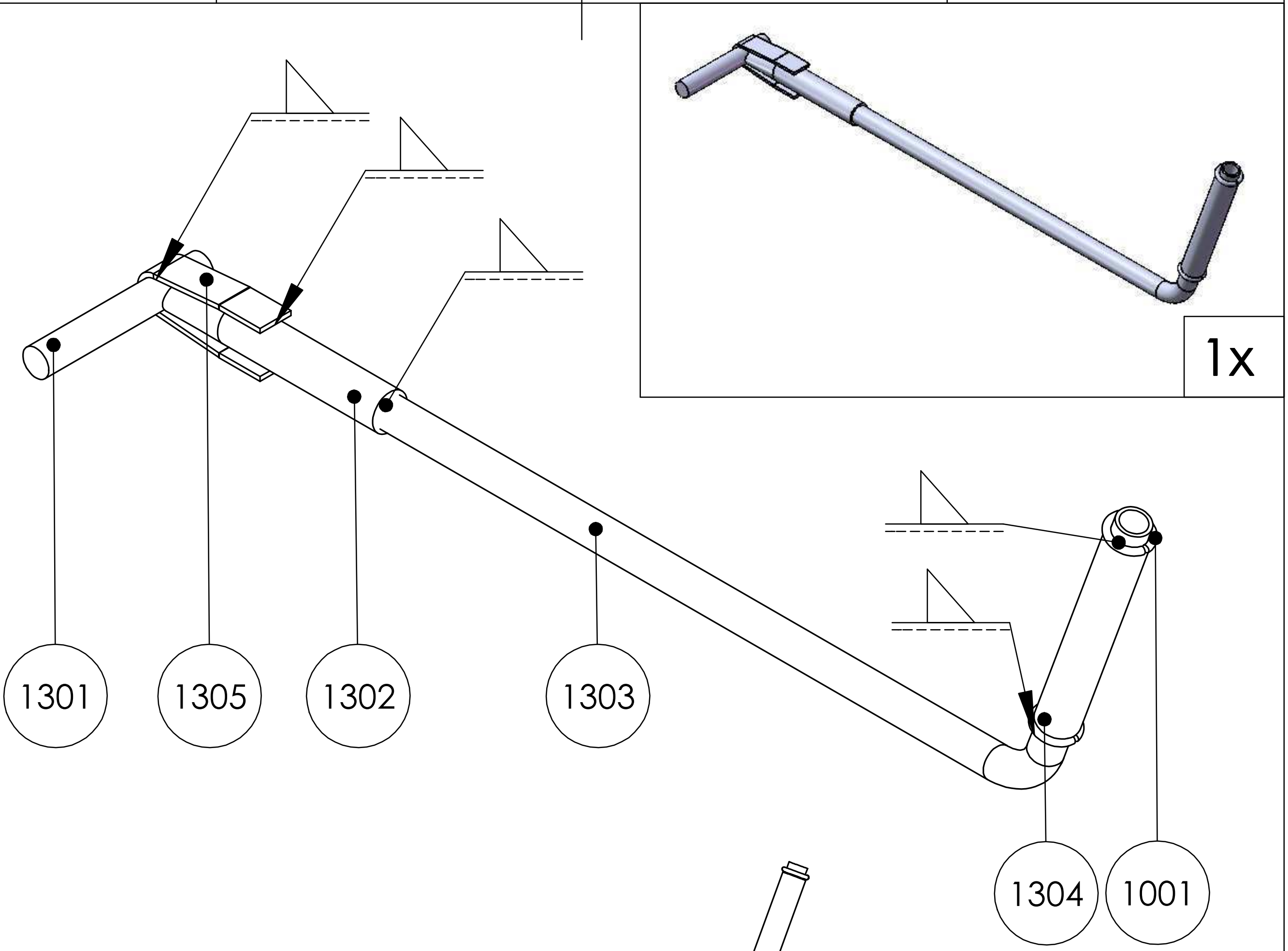
PRACTICA FOUNDATION

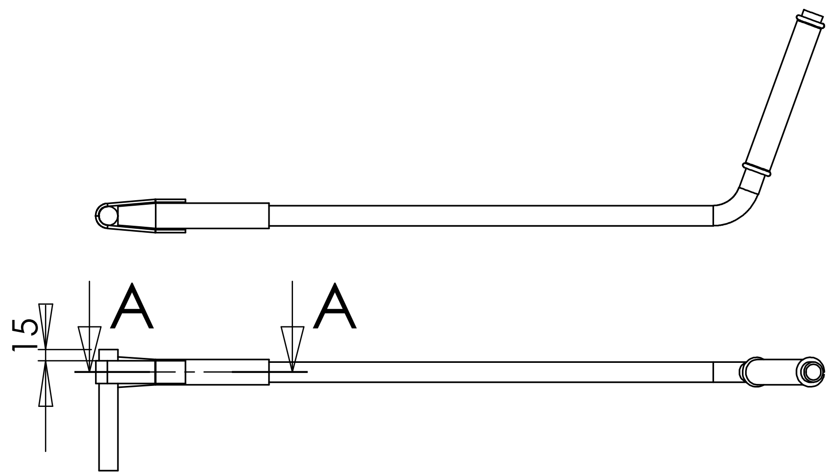
BASE MATERIAL: Round bar Ø8 x 80mm

TITLE: Grip ridge

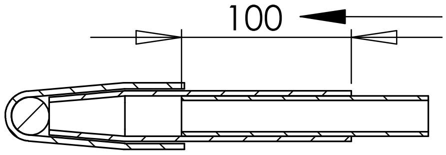
PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	1206	1:1	A4	8





SCALE 1:10

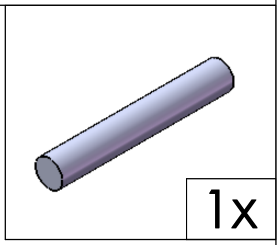


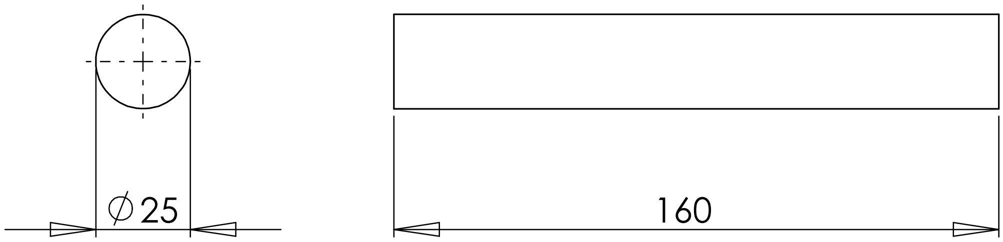
SECTION A-A

NO.	DESCRIPTION	QTY.
1001	Lock ring	2
1301	Axle	1
1302	Connecting pipe	1
1303	Handle	1
1304	Grip	1
1305	Reinforcement strip	1

PRACTICA FOUNDATION	BASE MATERIAL: Part specific	
PROJECT: Rota Sludge	TITLE: Arm	

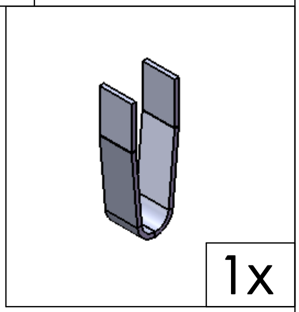
DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Rob Dedden	18-2-2011	Practica model - v1.0	1300	1:5	A4	9

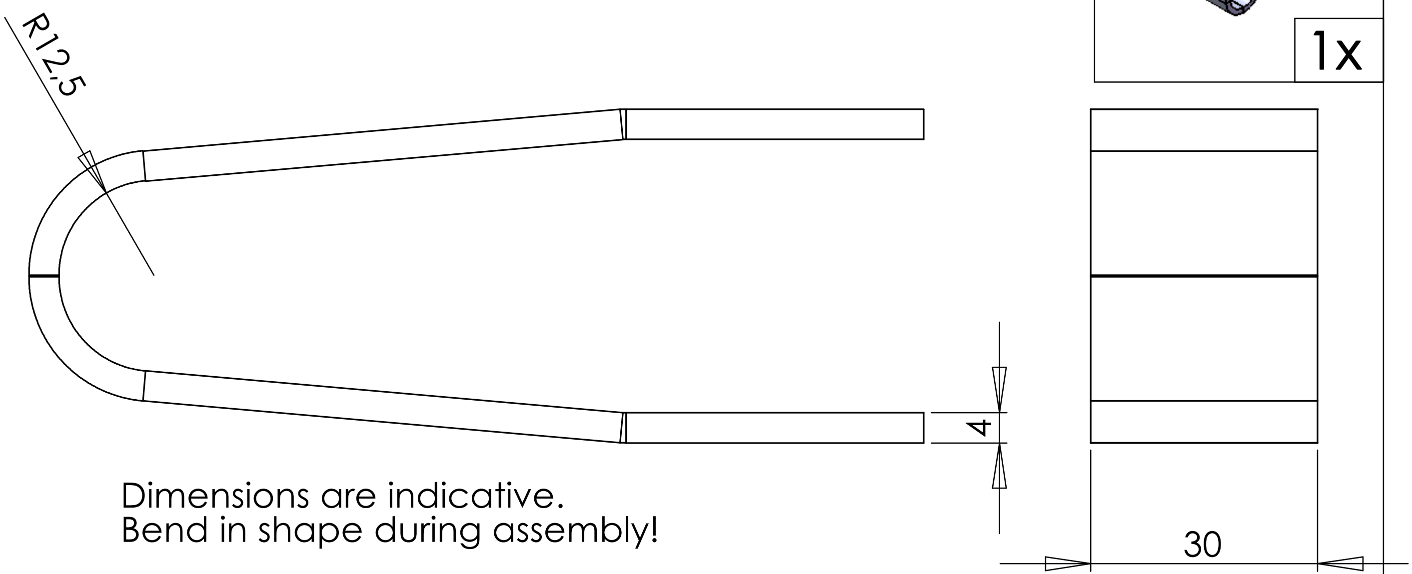




TITLE: **Axle**

BASE MATERIAL:	DWG NO.	SCALE:
Round bar Ø25 x 160mm	1301	1:2





Dimensions are indicative.
Bend in shape during assembly!

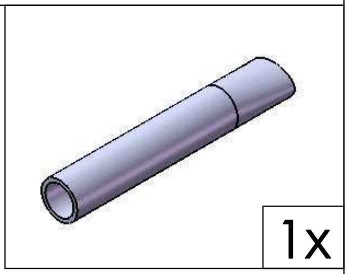
PRACTICA FOUNDATION

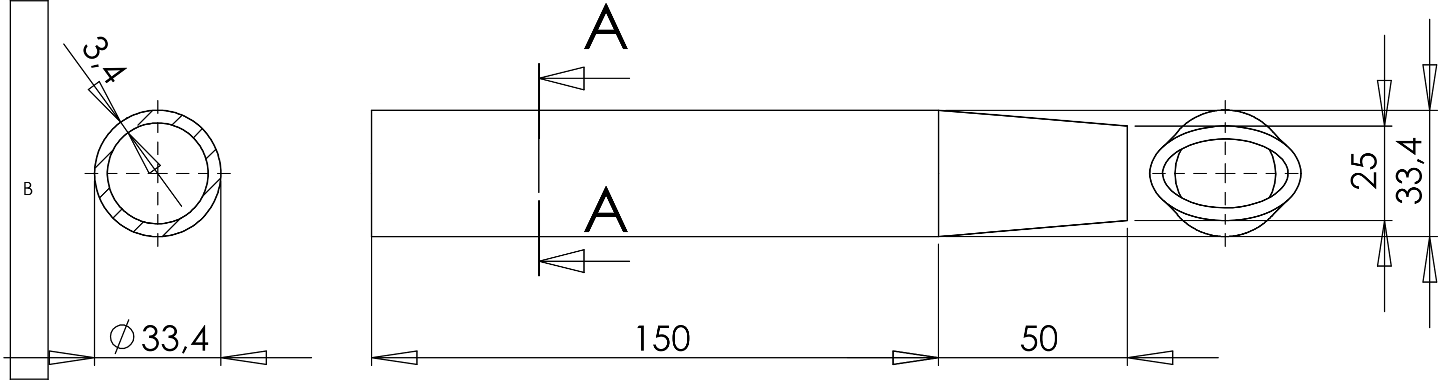
BASE MATERIAL: Fe36 strip 250 x 30 x 4mm

PROJECT: Rota Sludge

TITLE: **Reinforcement strip**

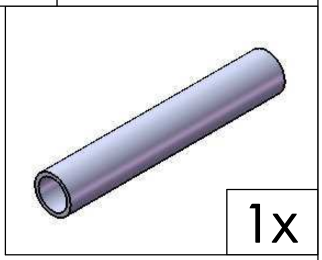
DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Rob Dedden	18-2-2011	Practica model - v1.0	1305	1:1	A4	10

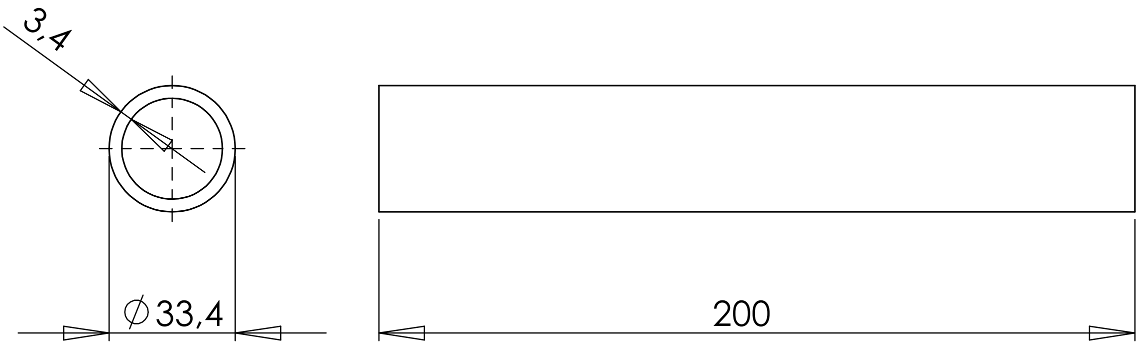




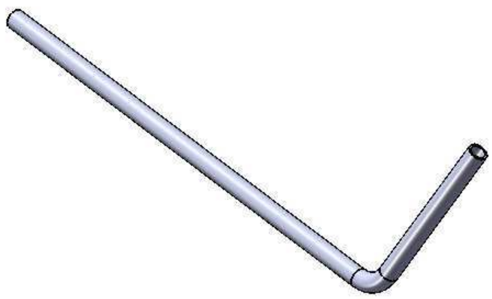
SECTION A-A

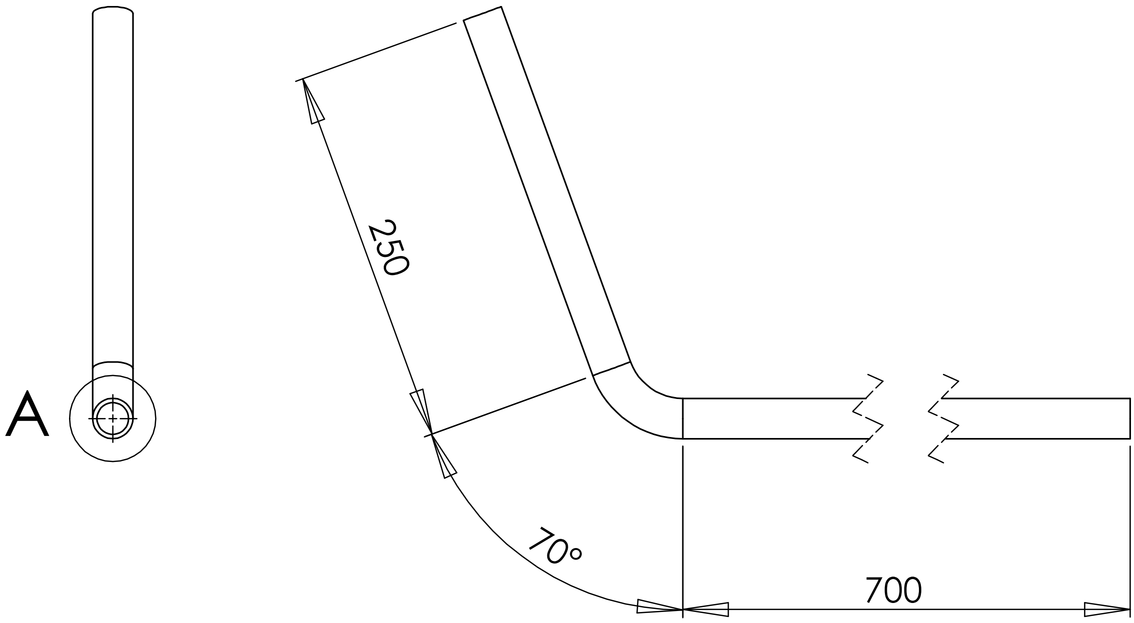
TITLE: Connecting pipe			
BASE MATERIAL: GI pipe NPS 1" x 200mm	DWG NO. 1302	SCALE: 1:2	

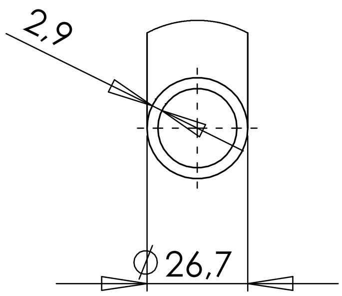




		PRACTICA FOUNDATION	BASE MATERIAL: GI pipe NPS 1" x 200mm		
		PROJECT: Rota Sludge	TITLE: Grip		
DRAWN BY: Rob Dedden	DATE: 18-2-2011	VERSION: Practica model - v1.0	DWG NO. 1304	SCALE: 1:2	FORMAT: A4 / PAGE NO. 1 1

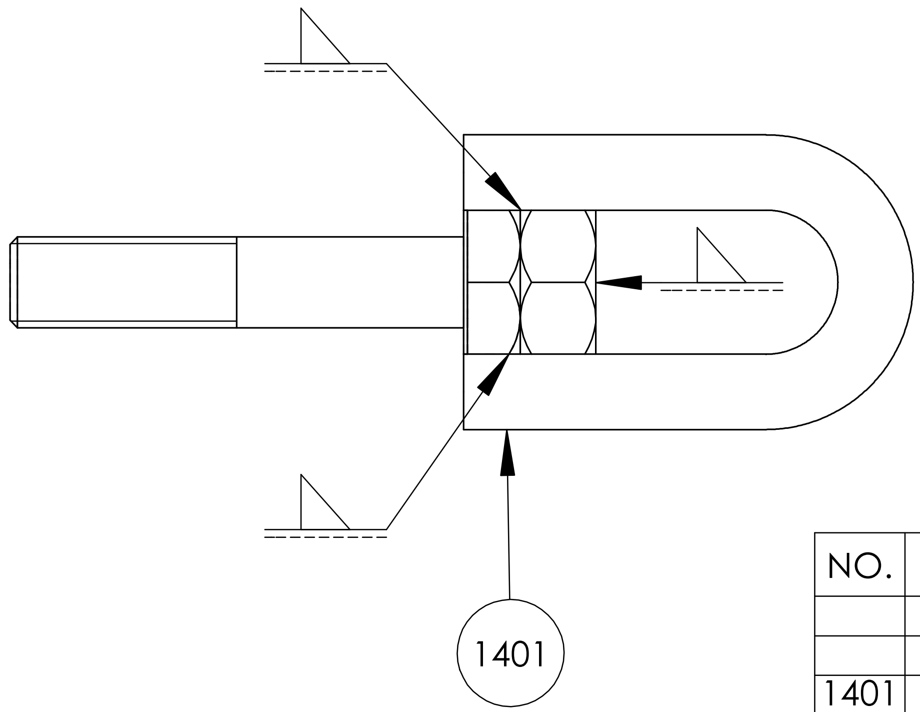


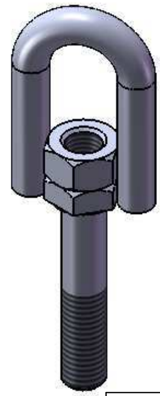




DETAIL A
SCALE 1 : 2

PRACTICA FOUNDATION	BASE MATERIAL: GI pipe NPS 3/4" x 1000mm			
PROJECT: Rota Sludge	TITLE: Handle			
DRAWN BY: Rob Dedden	DATE: 18-2-2011	VERSION: Practica model - v1.0	DWG NO. 1303	SCALE: 1:5
FORMAT: A4	PAGE NO. 1 2			





1x

NO.	DESCRIPTION	QTY.
	Bolt M12x60	1
	Nut M12	1
1401	Bolt wing	1

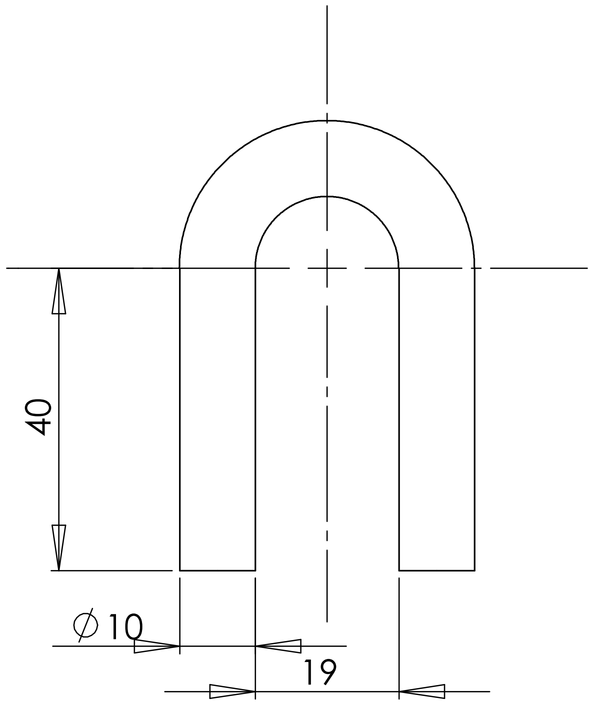
Weld nut on top of bolt.
Weld nut at the inside!

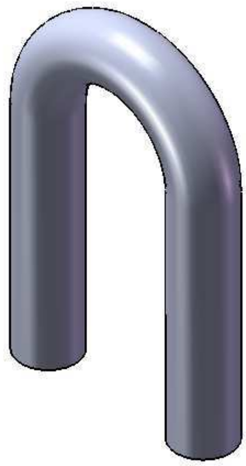
TITLE: Clamp bolt

BASE MATERIAL: Part specific

DWG NO. 1400

SCALE: 1:1





1x

PRACTICA FOUNDATION

BASE MATERIAL: Round bar Ø10 x 130

TITLE: Bolt wing

PROJECT: Rota Sludge

DRAWN BY: Erik den Toom

DATE: 18-2-2011

VERSION: Practica model - v1.0

DWG NO. 1401

SCALE: 1:1

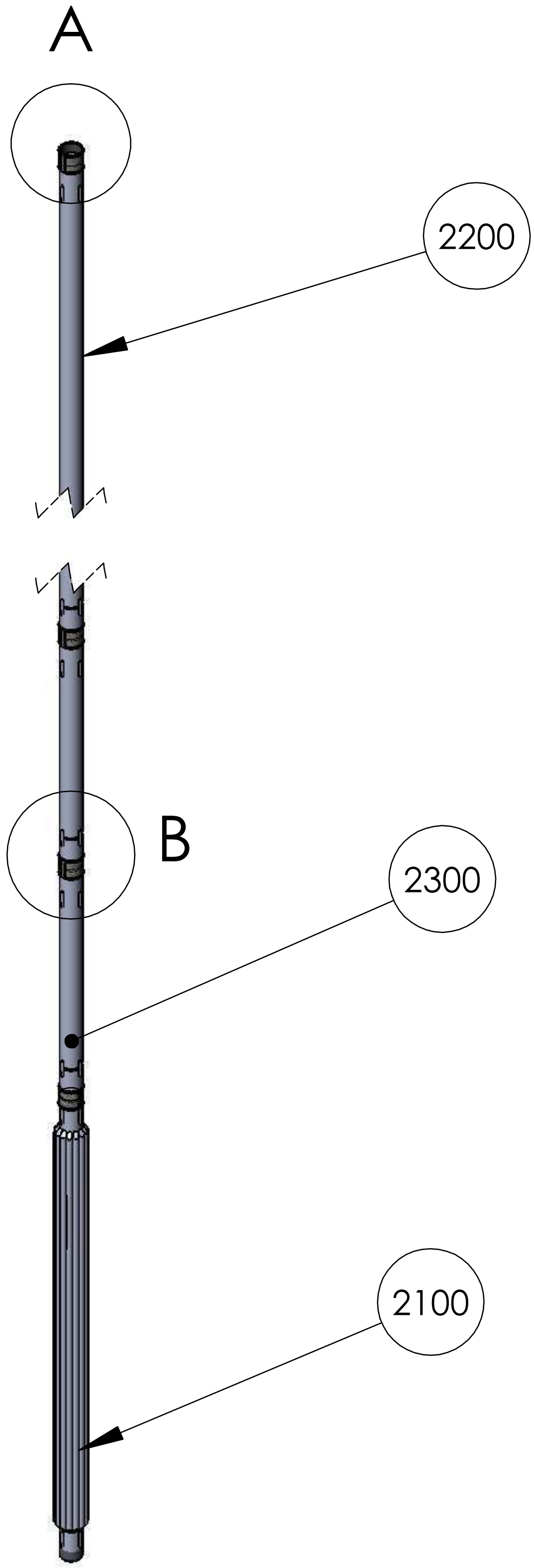
FORMAT: A4

PAGE NO. 13

1	2	3	4

DETAIL A
SCALE 1 : 5

DETAIL B
SCALE 1 : 5

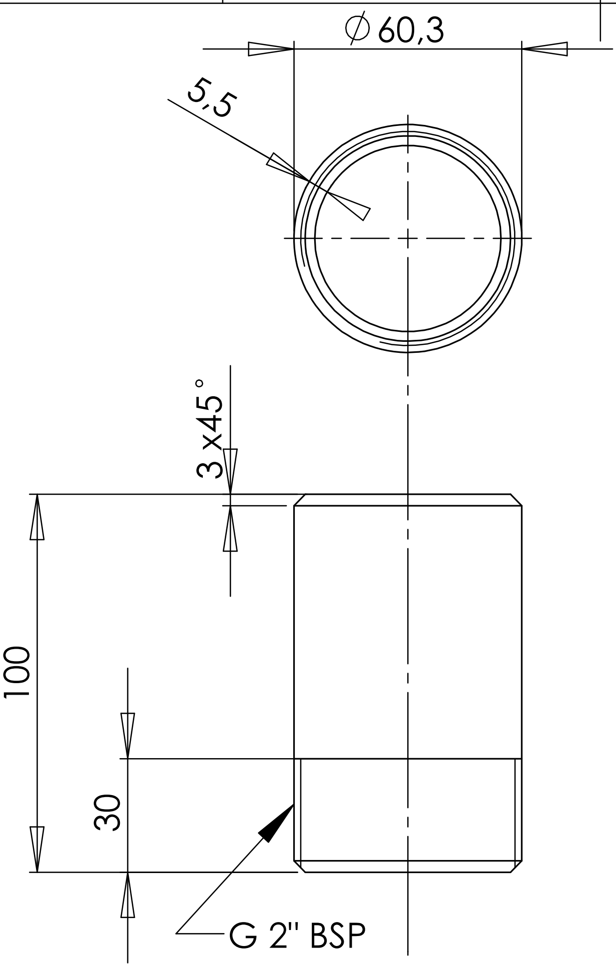


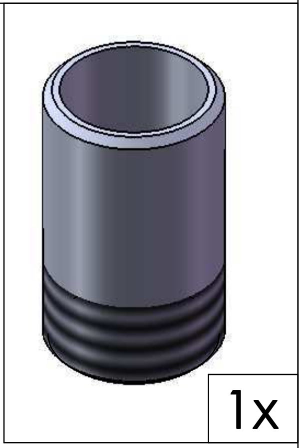
NO.	DESCRIPTION	QTY.
2100	Weighted pipe	1
2200	Drill pipe normal	1
2300	Drill pipe short	1

PRACTICA FOUNDATION

BASE MATERIAL:	Part specific
TITLE:	Drill string
PROJECT:	Rota Sludge
DRAWN BY:	Erik den Toom
DATE:	18-2-2011
VERSION:	Practica model - v1.0
DWG NO.	2000
SCALE:	1:20
FORMAT:	A4
PAGE NO.	1 4

1 2 3 4



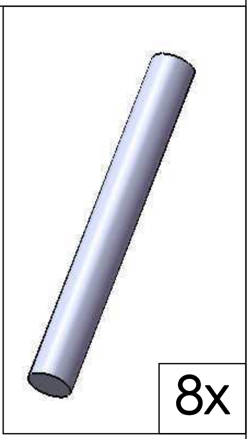


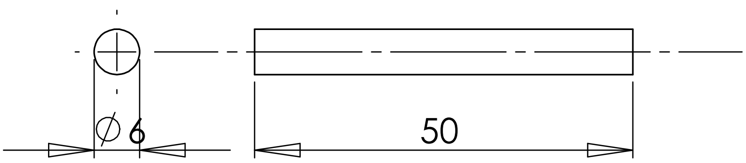
TITLE: Threaded pipe

BASE MATERIAL: GI pipe NPS XS 2" x 100mm

DWG NO. 2001

SCALE: 1:2





PRACTICA FOUNDATION

BASE MATERIAL: Reinforcement bar Ø6 x 50mm

TITLE: Rib

PROJECT: Rota Sludge

DRAWN BY: Erik den Toom

DATE: 21-2-2011

VERSION: Practica model - v1.0

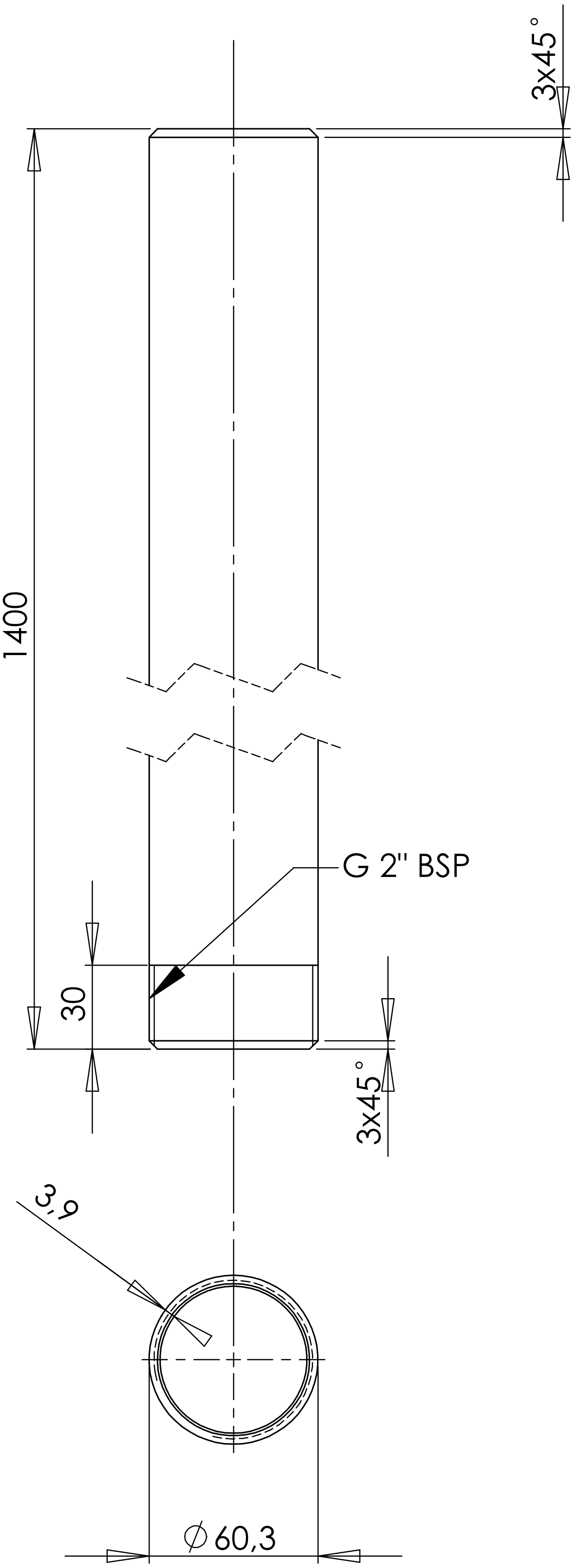
DWG NO. 2003

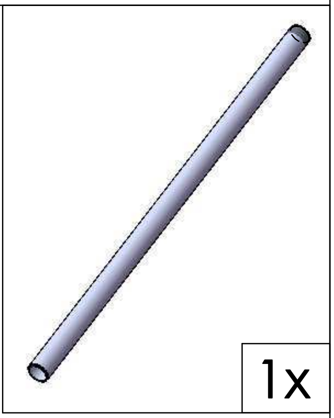
SCALE: 1:1

FORMAT: A4

PAGE NO. 15

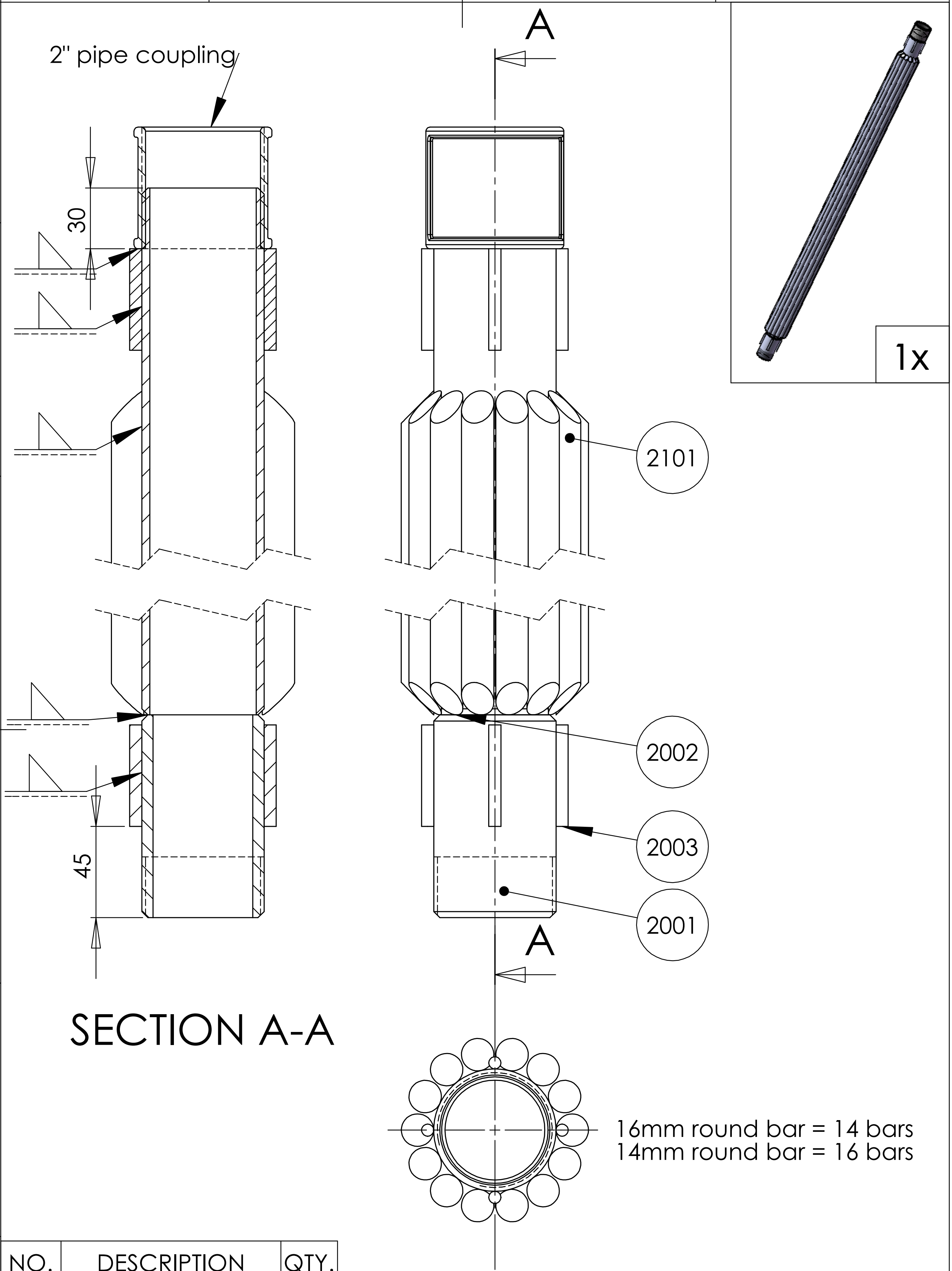
1	2	3	4





1x

		PRACTICA FOUNDATION	BASE MATERIAL: GI pipe NPS 2" x 1400mm				
		PROJECT: Rota Sludge	TITLE: Midsection long				
DRAWN BY: Erik den Toom	DATE: 18-2-2011	VERSION: Practica model - v1.0	DWG NO. 2002	SCALE: 2:5	FORMAT: A4	PAGE NO. 16	



NO.	DESCRIPTION	QTY.
	Pipe coupling	1
2001	Threaded pipe	1
2002	Midsection normal	1
2003	Rib	8
2101	Weight	14

PRACTICA FOUNDATION

BASE MATERIAL: Part specific

TITLE: Weighted pipe

PROJECT: Rota Sludge

DRAWN BY: Erik den Toom

DATE: 18-2-2011

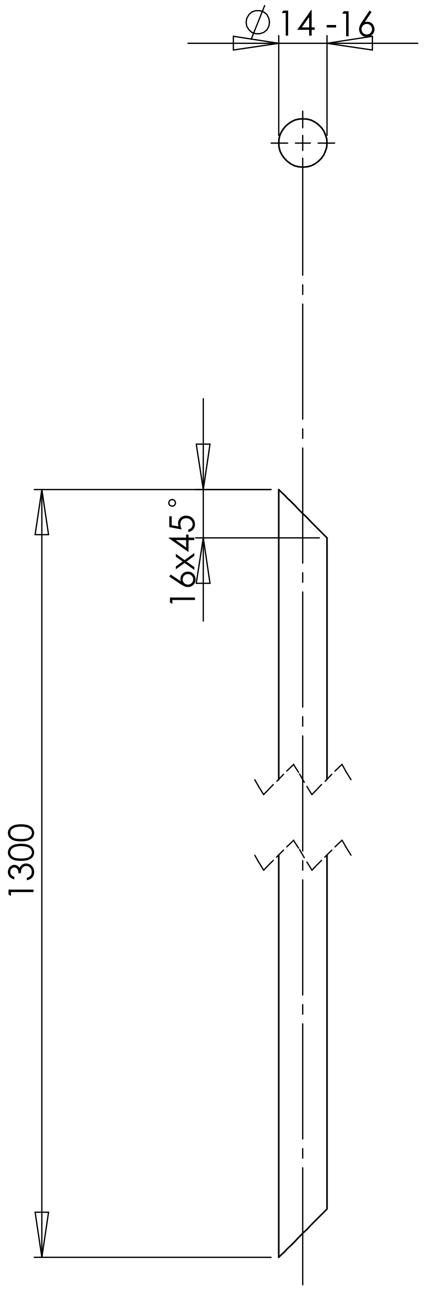
VERSION: Practica model - v1.0

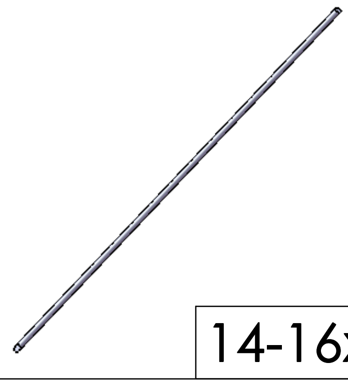
DWG NO. 2100

SCALE: 2:5

FORMAT: A4

PAGE NO. 17





14-16x

16mm round bar = 14 bars
14mm round bar = 16 bars

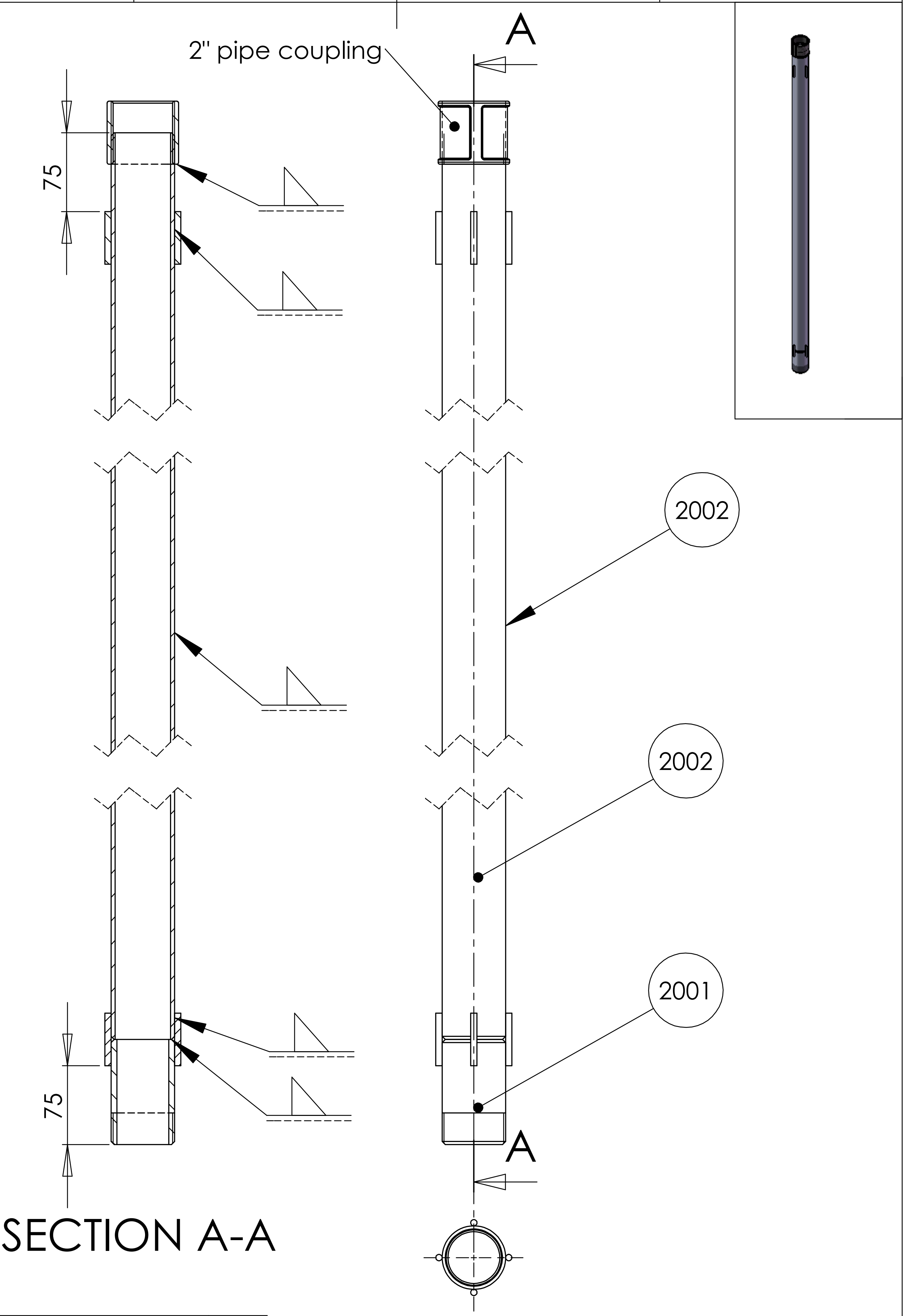
PRACTICA FOUNDATION

BASE MATERIAL: Reinforcement bar Ø16 x 1300mm

TITLE: Weight

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	18-2-2011	Practica model - v1.0	2101	2:5	A4	18



NO.	DESCRIPTION	QTY.
	Pipe coupling	1
2001	Threaded pipe	1
2002	Midsection normal	1
2003	Rib	8

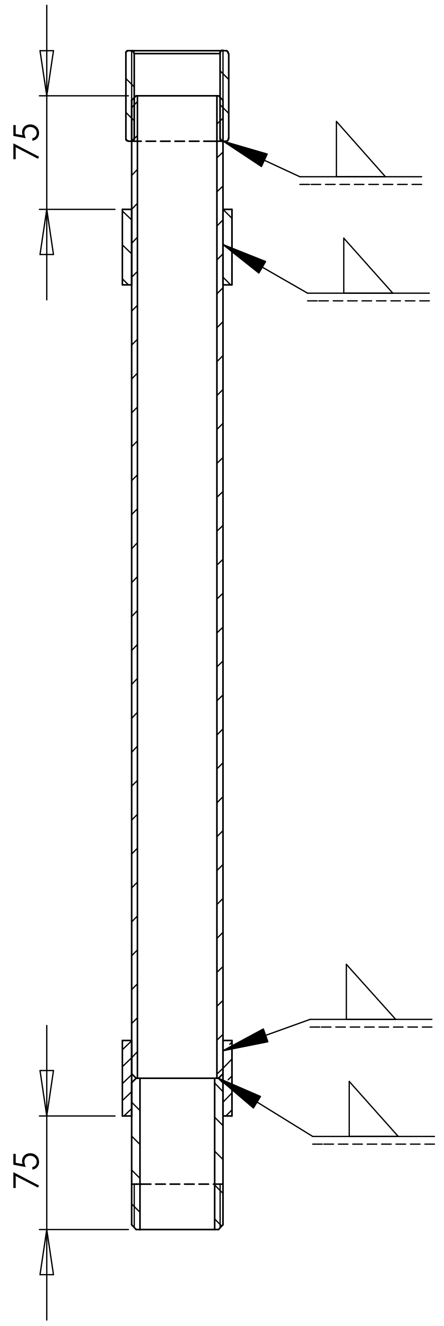
PRACTICA FOUNDATION

BASE MATERIAL: Part specific

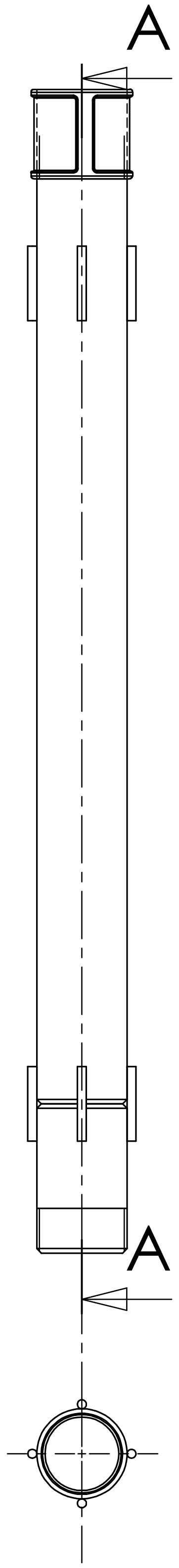
TITLE: Drill pipe normal

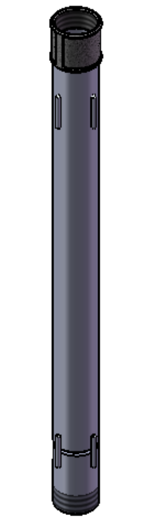
PROJECT: Rota Sludge

DRAWN BY: Erik den Toom | DATE: 18-2-2011 | VERSION: Practica model - v1.0 | DWG NO. 2200 | SCALE: 1:5 | FORMAT: A4 | PAGE NO. 19



SECTION A-A





NO.	DESCRIPTION	QTY.
	Pipe coupling	1
2001	Threaded pipe	1
2003	Rib	8
2301	Midsection short	1

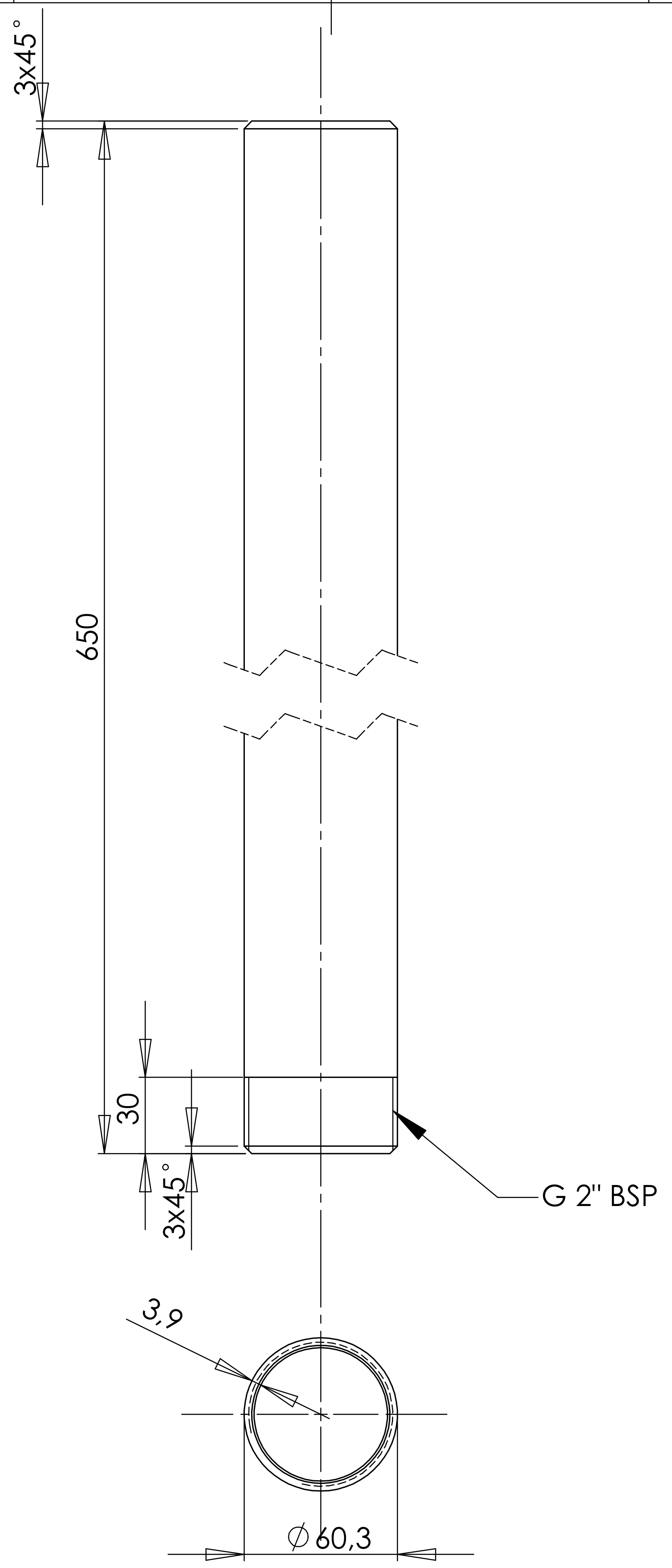
PRACTICA FOUNDATION

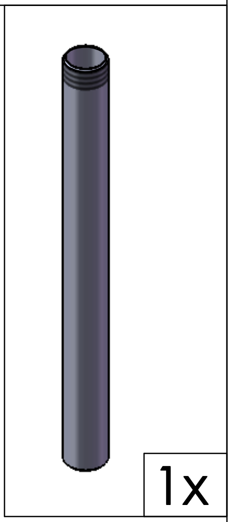
BASE MATERIAL: Part specific

TITLE: Drill pipe short

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	20-2-2011	Practica model - v1.0	2300	1:5	A4	20





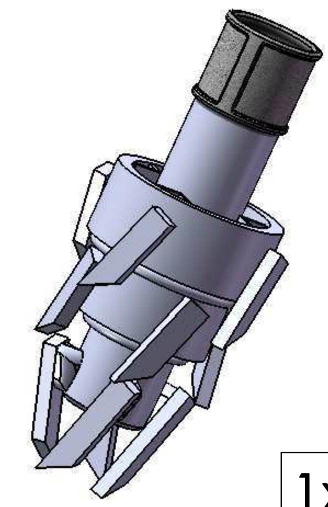
PRACTICA FOUNDATION

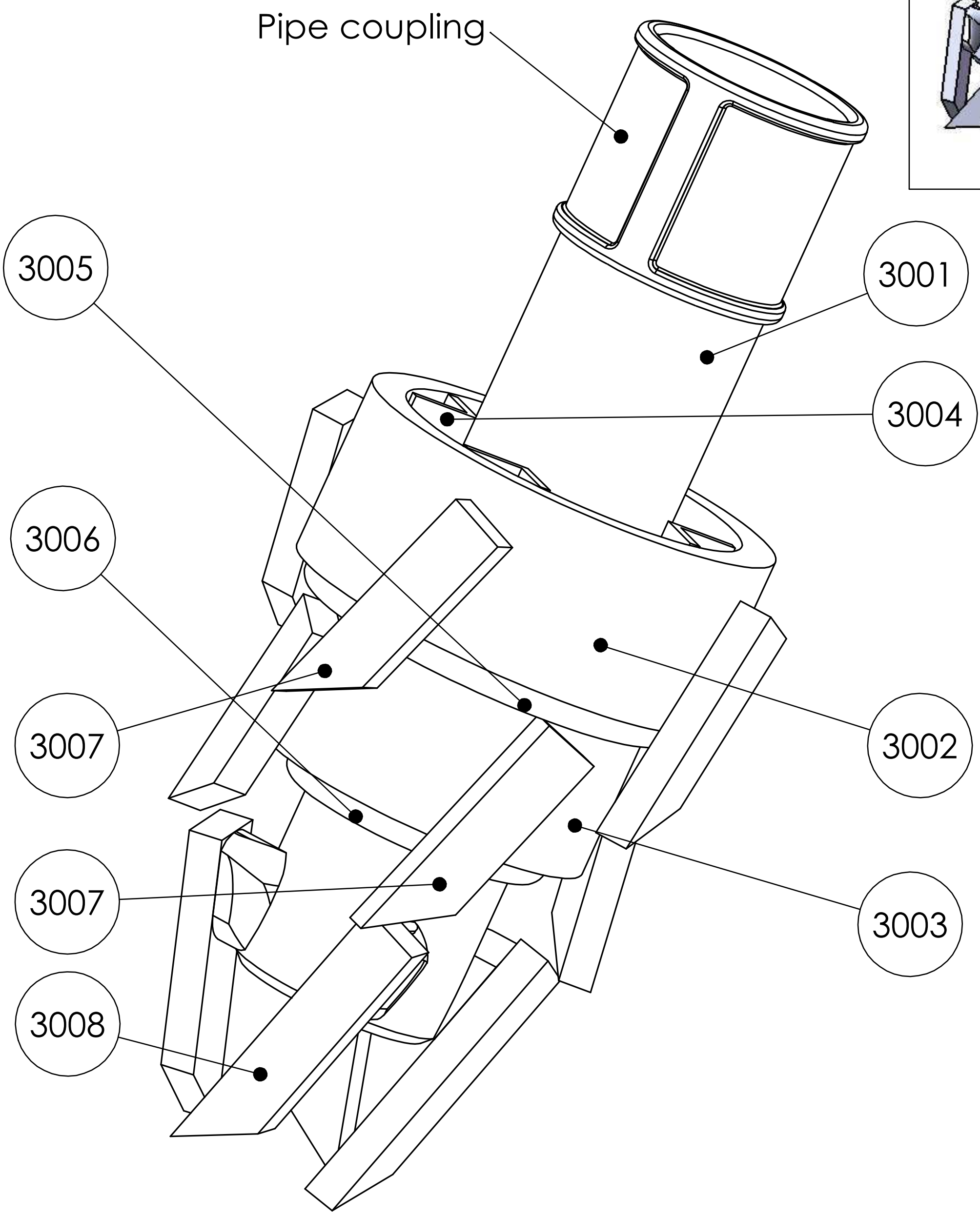
BASE MATERIAL: GI pipe NPS 2" x 650mm

TITLE: **Midsection short**

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	20-2-2011	Practica model - v1.0	2301	2:5	A4	21


1x



NO.	DESCRIPTION	QTY.
3001	Central pipe	1
3002	Upper ring	1
3003	Lower ring	1
3004	Ring support	4
3005	Upper welding support	1
3006	Lower welding support	1
3007	Tooth short	8
3008	Tooth long	4
	Pipe coupling	1

PRACTICA FOUNDATION

BASE MATERIAL: Part specific

TITLE: Drill bit

PROJECT: Rota Sludge

DRAWN BY: Rob Dedden

DATE: 4-3-2011

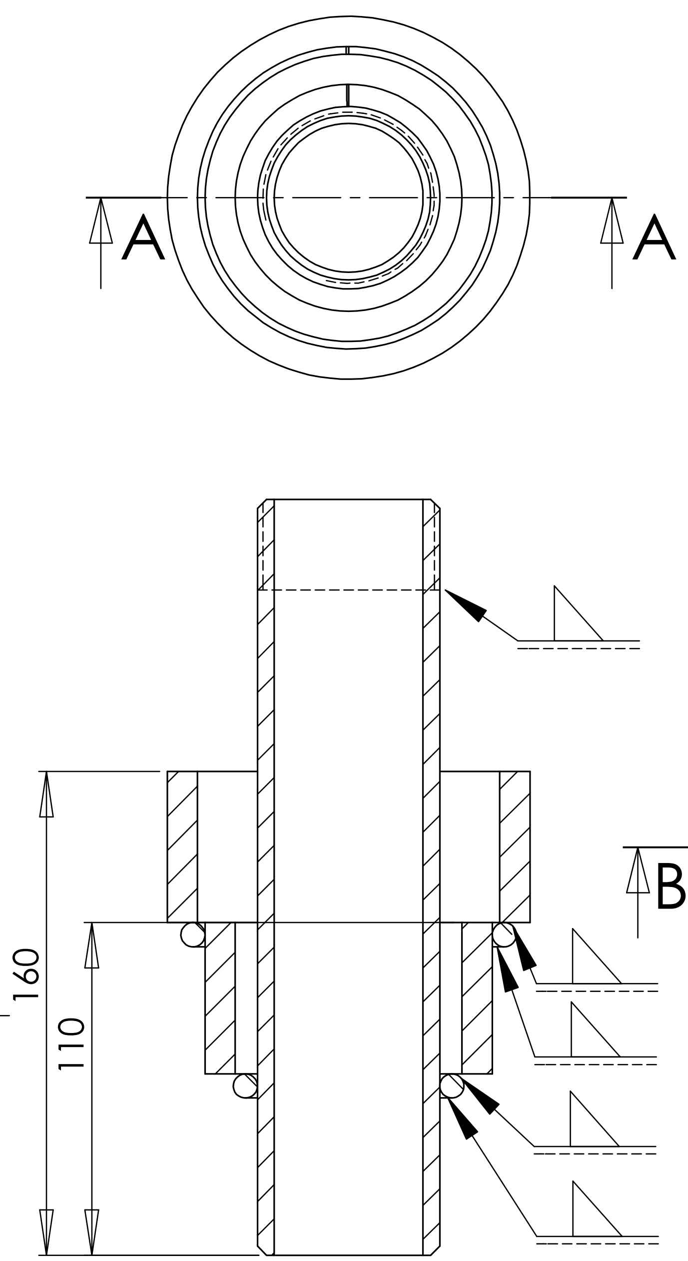
VERSION: Practica model - v1.0

DWG NO. 3000

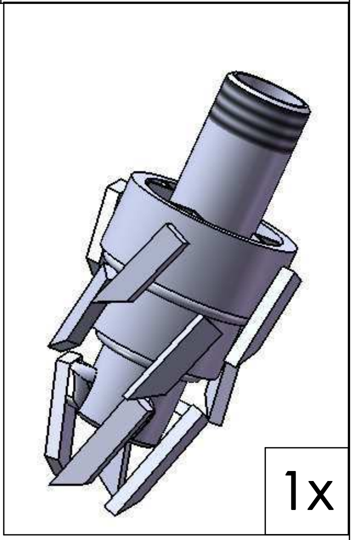
SCALE: 1:2

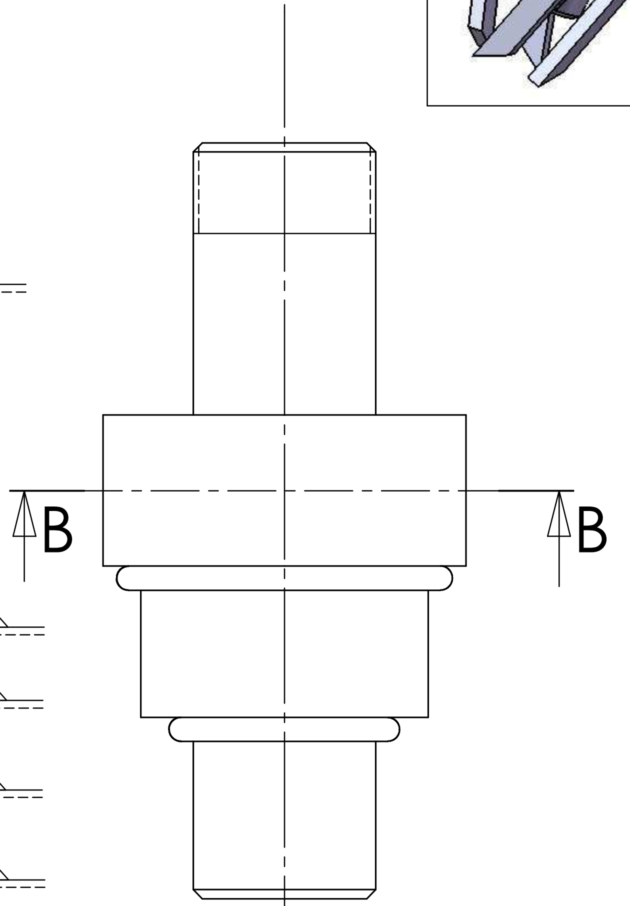
FORMAT: A4

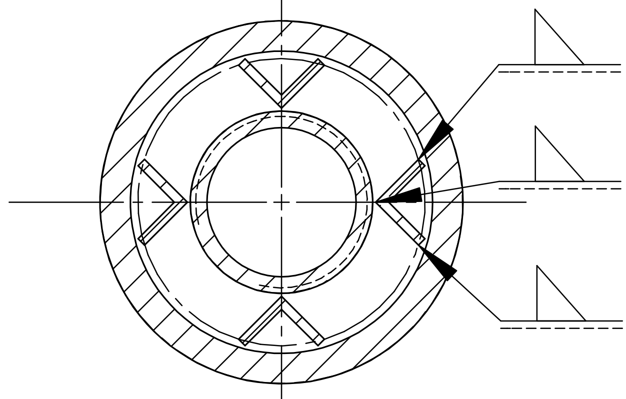
PAGE NO. 22



SECTION A-A







SECTION B-B

NO.	DESCRIPTION	QTY.
3001	Central pipe	1
3002	Upper ring	1
3003	Lower ring	1
3004	Ring support	4
3005	Upper welding support	1
3006	Lower welding support	1
3007	Tooth short	8
3008	Tooth long	4
	Pipe coupling	1

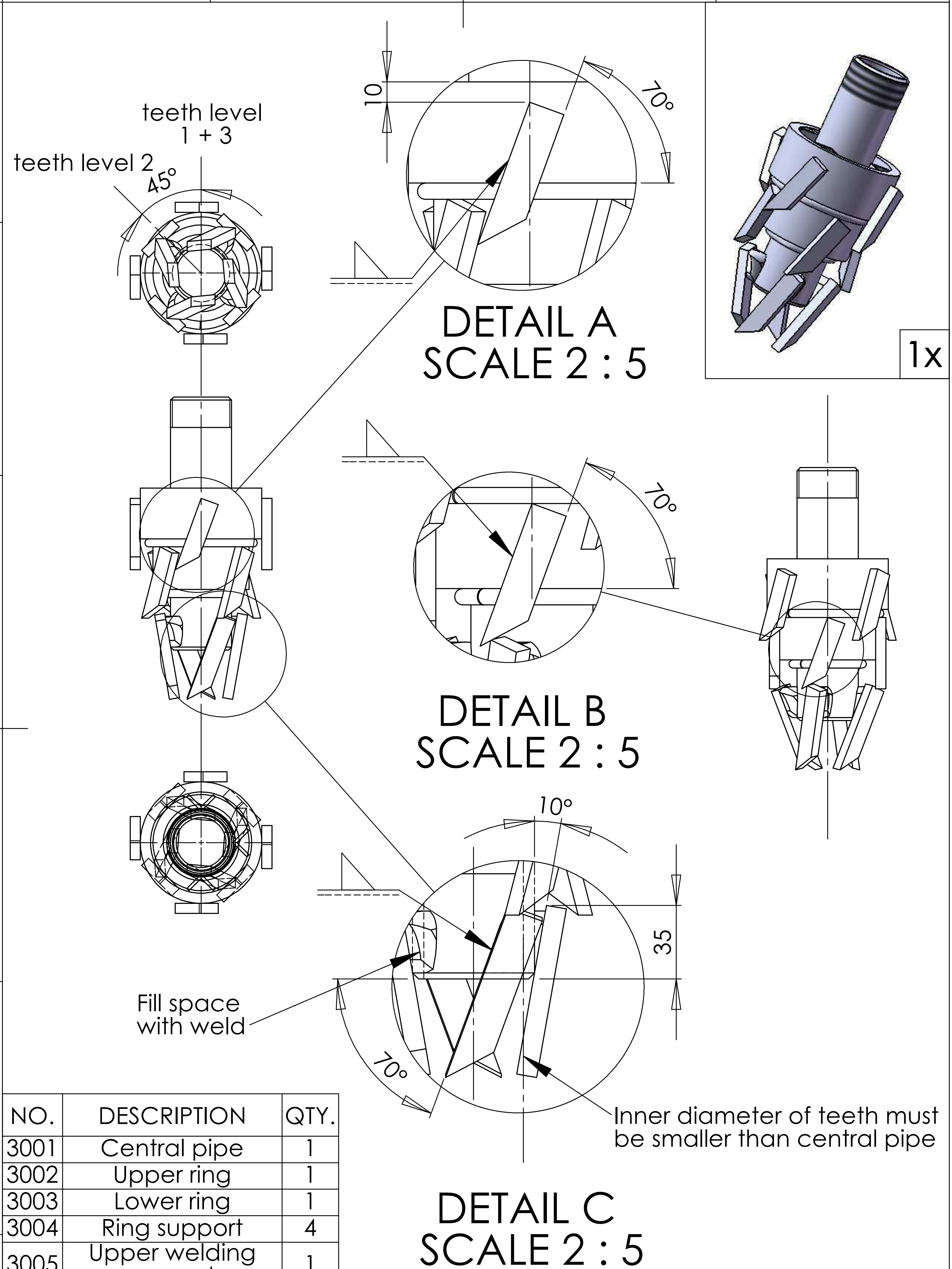
PRACTICA FOUNDATION

BASE MATERIAL: Part specific

TITLE: Drill bit

PROJECT: Rota Sludge

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Rob Dedden	5-3-2011	Practica model - v1.0	3000-DIMS-1	2:5	A4	23



NO.	DESCRIPTION	QTY.
3001	Central pipe	1
3002	Upper ring	1
3003	Lower ring	1
3004	Ring support	4
3005	Upper welding support	1
3006	Lower welding support	1
3007	Tooth short	8
3008	Tooth long	4
	Pipe coupling	1

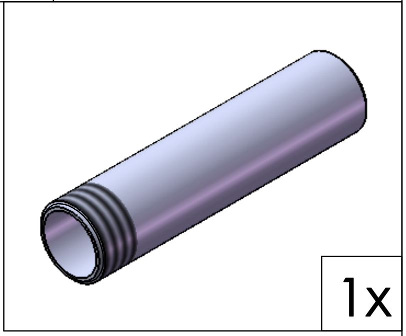
PRACTICA FOUNDATION

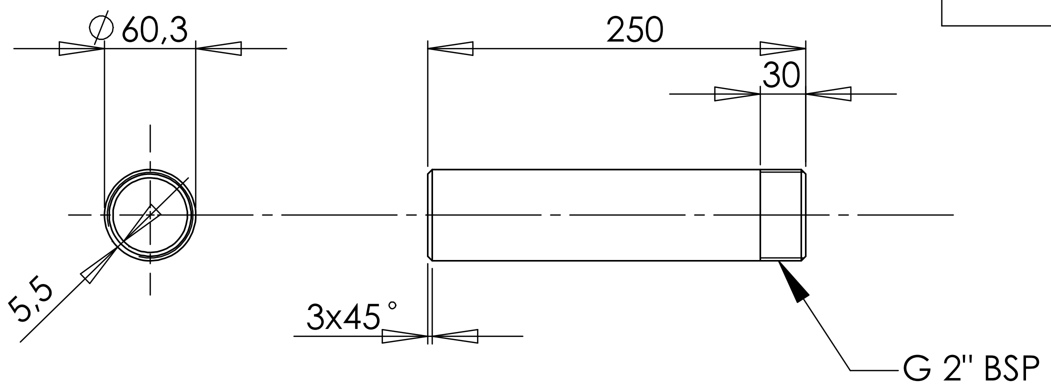
BASE MATERIAL: Part specific

TITLE: Drill bit

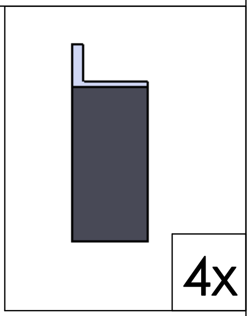
PROJECT: Rota Sludge

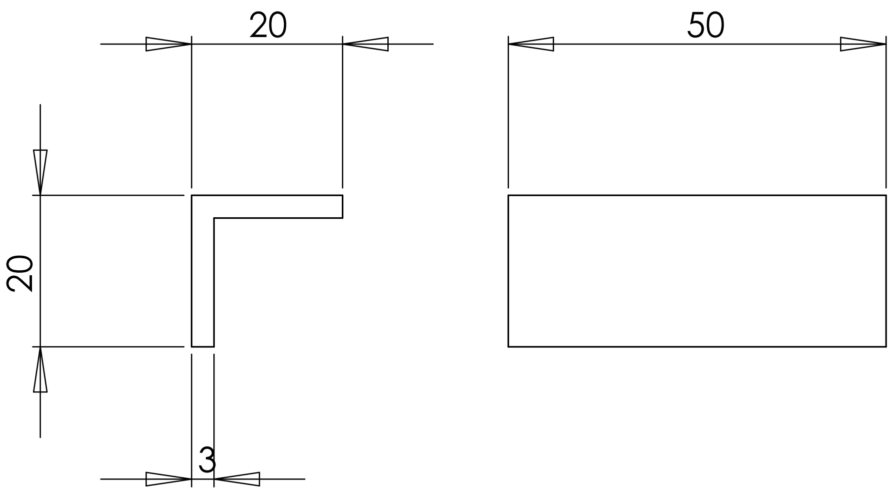
DRAWN BY: Rob Dedden | DATE: 5-3-2011 | VERSION: Practica model - v1.0 | DWG NO. 3000-DIMS-2 | SCALE: 1:5 | FORMAT: A4 | PAGE NO. 24



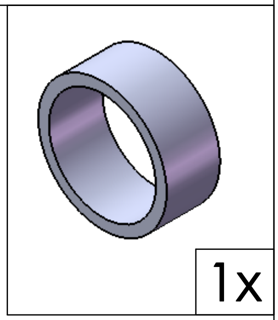


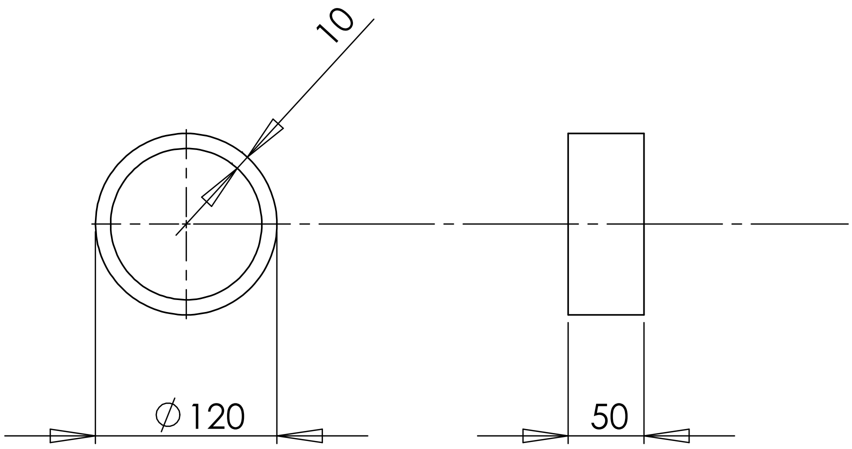
TITLE: Central pipe		
BASE MATERIAL: GI pipe NPS XS 2" x 250mm	DWG NO. 3001	SCALE: 1:5



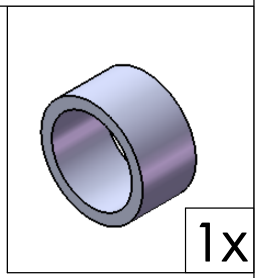


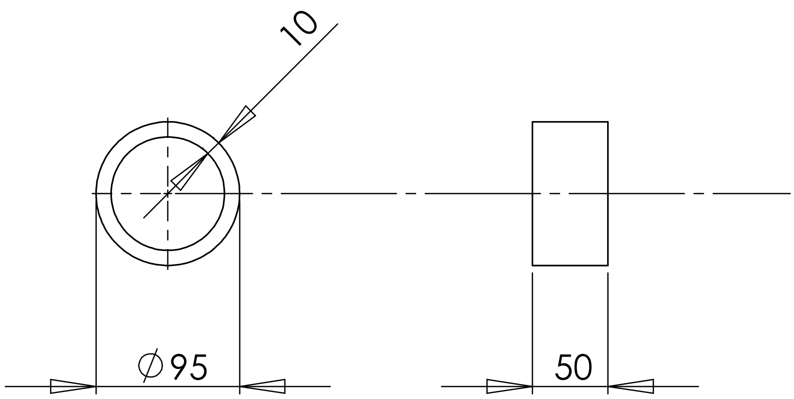
PRACTICA FOUNDATION	BASE MATERIAL: Fe36 angle iron 25 x 25 x 3 x 50mm				
PROJECT: Rota Sludge	TITLE: Ring support				
DRAWN BY: Rob Dedden	DATE: 20-2-2011	VERSION: Practica model - v1.0	DWG NO. 3004	SCALE: 1:1	FORMAT: A4



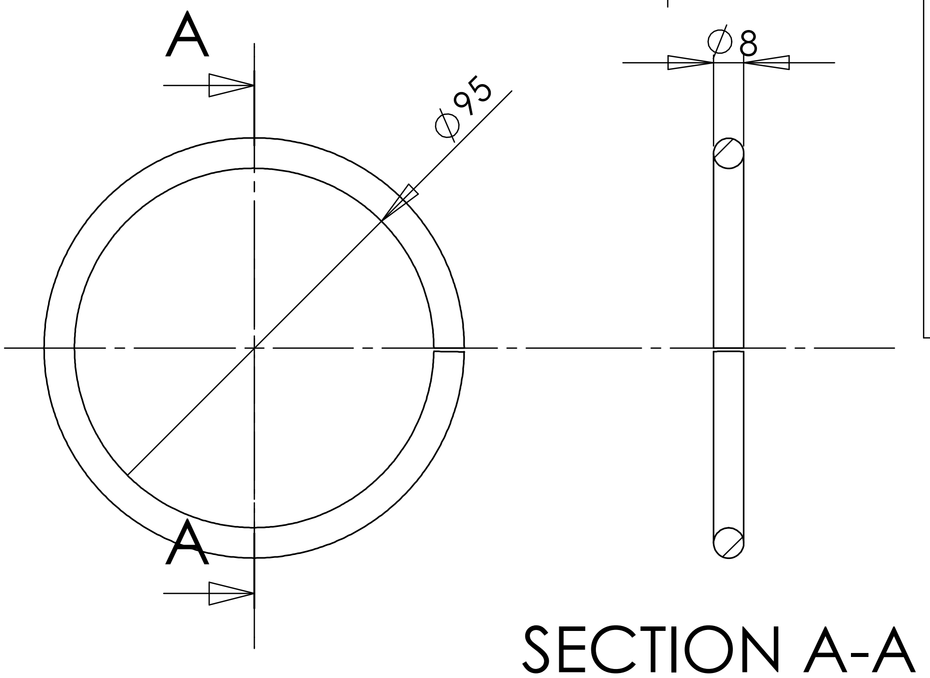


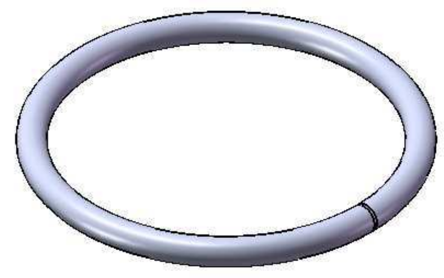
TITLE: Upper ring		
BASE MATERIAL: Fe36 pipe Ø120 x 10 x 50mm	DWG NO. 3002	SCALE: 1:5





		PRACTICA FOUNDATION	BASE MATERIAL: Fe36 pipe 95 x 10 x 50mm		
		PROJECT: Rota Sludge	TITLE: Lower ring		
DRAWN BY: Rob Dedden	DATE: 20-2-2011	VERSION: Practica model - v1.0	DWG NO. 3003	SCALE: 1:5	FORMAT: A4

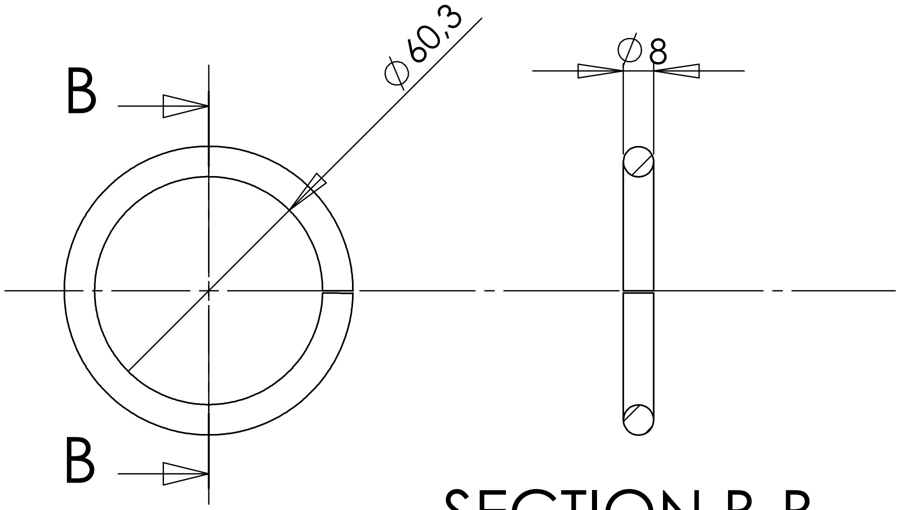


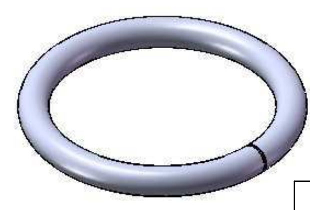


1x

SECTION A-A
SCALE 1 : 2

TITLE:	Upper welding support
BASE MATERIAL: Reinforcement bar Ø8 x 320	DWG NO. 3005 · SCALE: 1:1

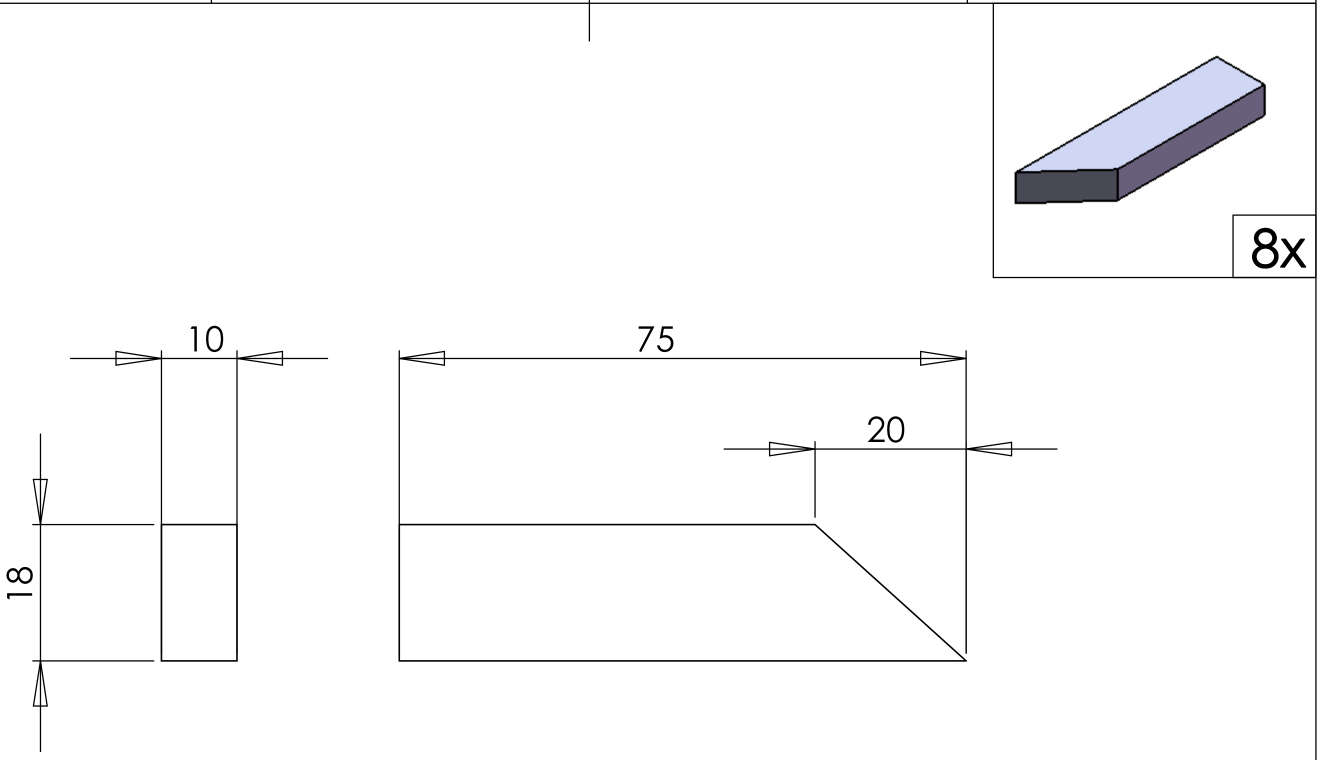




1x

SECTION B-B
SCALE 1 : 2

PRACTICA FOUNDATION	BASE MATERIAL: Reinforcement bar Ø8 x 200mm					
PROJECT: Rota Sludge	TITLE: Lower welding support					
DRAWN BY: Rob Dedden	DATE: 20-2-2011	VERSION: Practica model - v1.0	DWG NO. 3006	SCALE: 1:2	FORMAT: A4	PAGE NO. 27

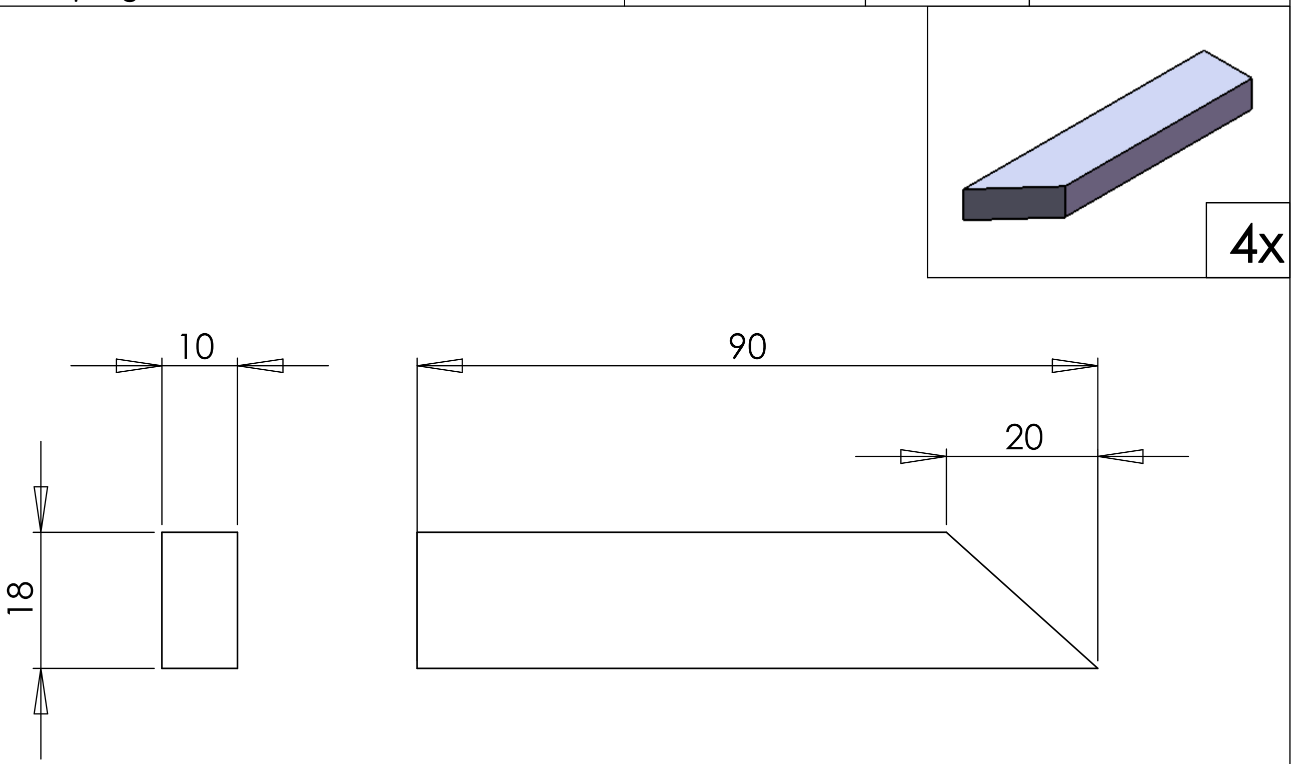


TITLE: **Tooth short**

BASE MATERIAL: Leaf spring

DWG NO. 3007

SCALE: 1:1



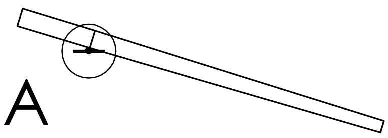
PRACTICA FOUNDATION

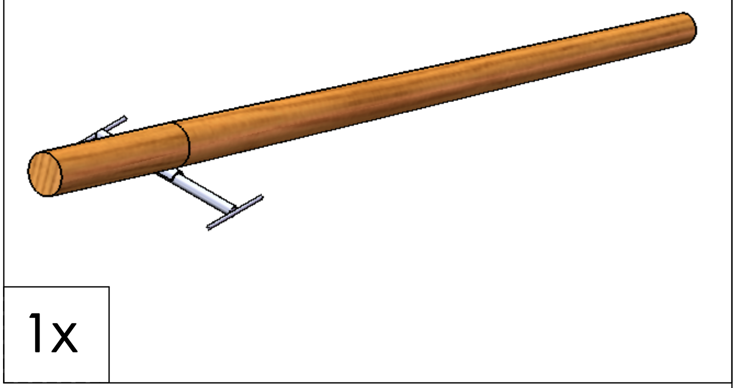
BASE MATERIAL: Leaf spring

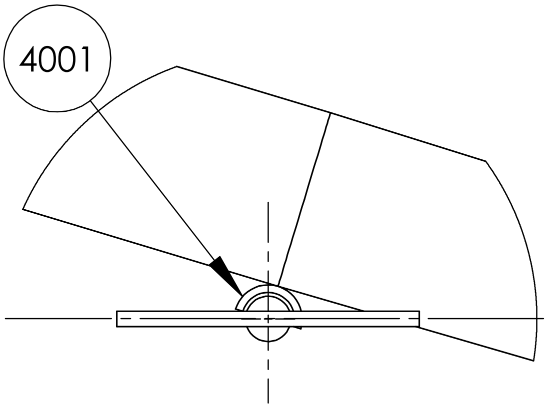
TITLE: **Tooth long**

PROJECT: Rota Sludge

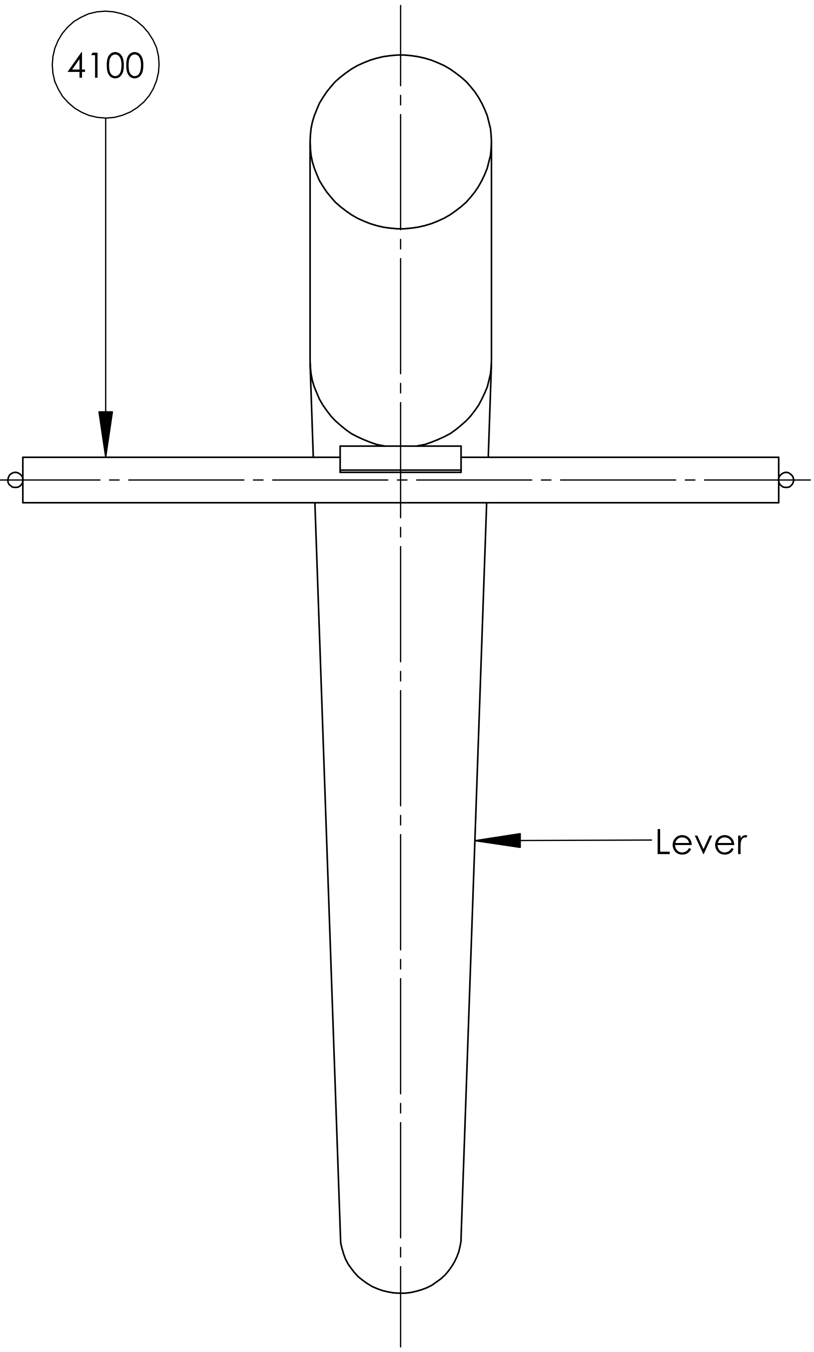
DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Rob Dedden	12-12-2010	Practica model - v1.0	3008	1:1	A4	28







DETAIL A
SCALE 1 : 5



NO.	DESCRIPTION	QTY.
	Lever	1
4001	Half bush	1
4100	Axle	1

PRACTICA FOUNDATION

BASE MATERIAL: Part specific

TITLE: Axle

PROJECT: Rota Sludge

DRAWN BY: Erik den Toom

DATE: 21-2-2011

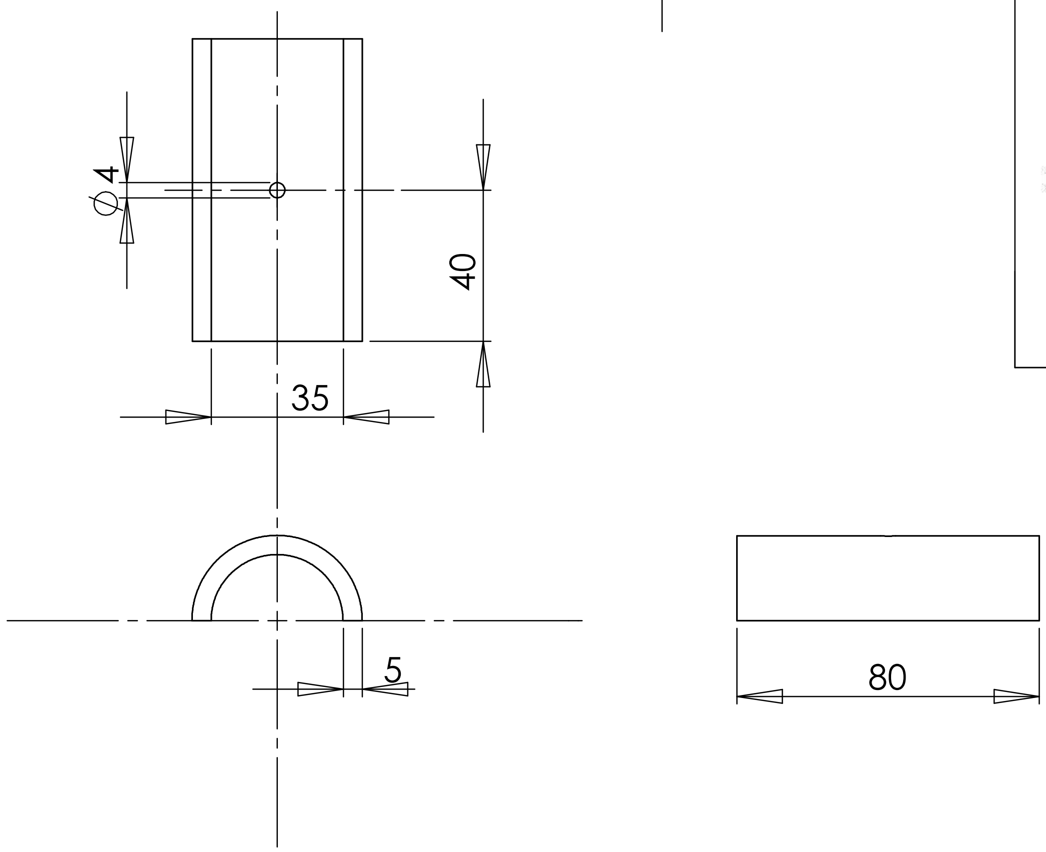
VERSION: Practica model - v1.0

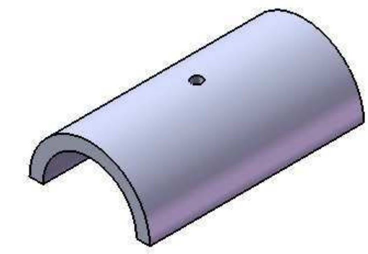
DWG NO. 4000

SCALE: 1:5

FORMAT: A4

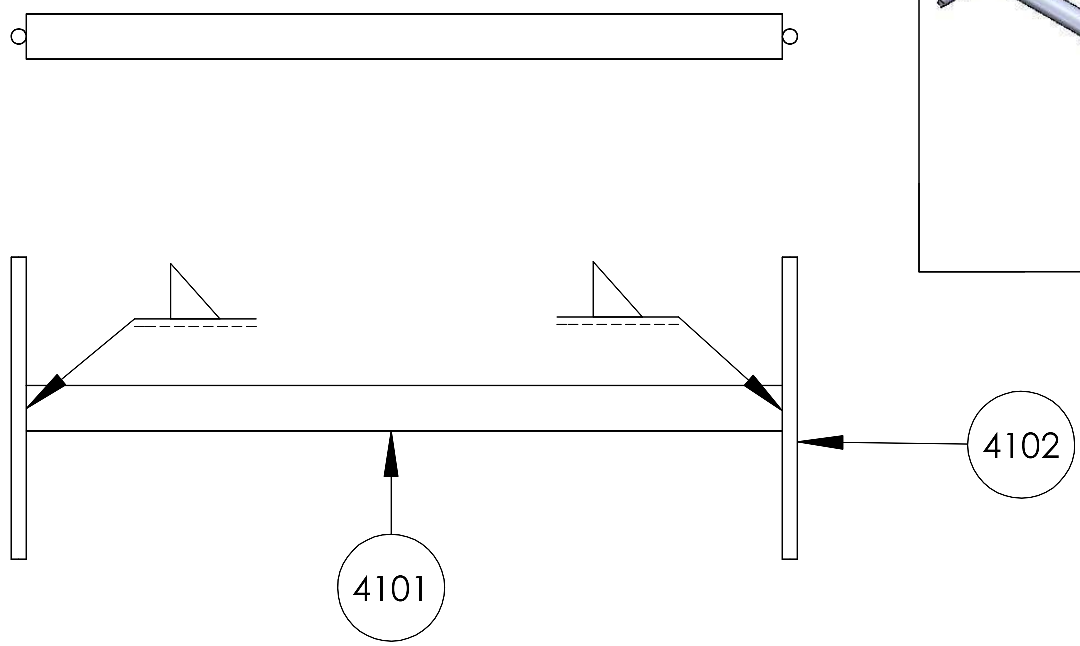
PAGE NO. 29

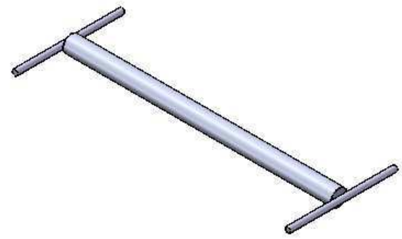




1x

TITLE:	Half bush
BASE MATERIAL: Fe36 strip 80 x 5 x 70mm	DWG NO. 4001
SCALE: 1:2	

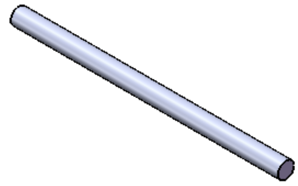


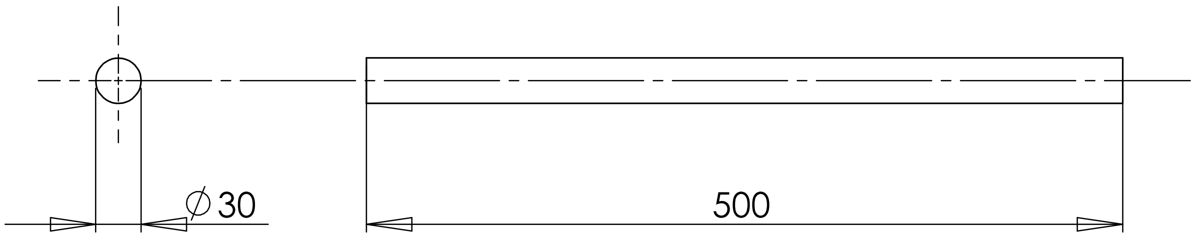


1x

NO.	DESCRIPTION	QTY.
4101	Axle	1
4102	Axle end stop	2

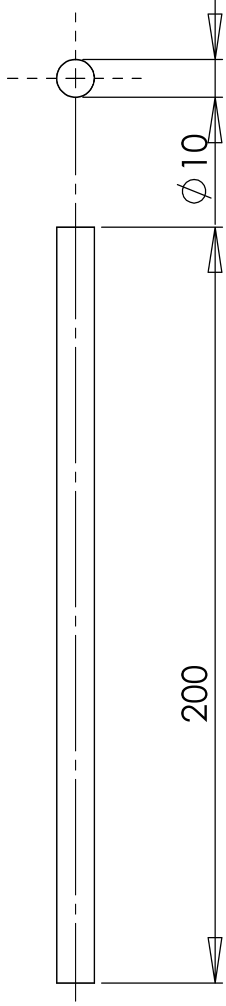
BASE MATERIAL:	Part specific
TITLE:	Axle
PROJECT:	Rota Sludge
DRAWN BY:	Erik den Toom
DATE:	21-2-2011
VERSION:	Practica model - v1.0
DWG NO.	4100
SCALE:	1:5
FORMAT:	A4
PAGE NO.	30





TITLE: **Axle**

BASE MATERIAL:	DWG NO.	SCALE:
Round bar Ø30 x 500mm	4101	1:5



PRACTICA FOUNDATION

PROJECT: Rota Sludge

BASE MATERIAL: Round bar Ø10 x 200mm

TITLE: **Axle end stop**

DRAWN BY:	DATE:	VERSION:	DWG NO.	SCALE:	FORMAT:	PAGE NO.
Erik den Toom	21-2-2011	Practica model - v1.0	4102	1:1	A4	31