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Federal Institute
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and Natural Resources



Ministry of Agriculture,
Water and Forestry

2016

THE INCREDIBLE ADVENTURES OF **H₂O** & HIS FRIENDS





BE WATER WISE!

Groundwater Management in the North of Namibia presents: **The incredible adventures of H₂O & his friends**

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FOREWORD

"WATER IS LIFE! ". AS MUCH AS THIS PHRASE IS USED, THERE ARE FEW COUNTRIES WHERE THIS FACT DETERMINES MORE OUR DAILY LIFE THAN IN DRY NAMIBIA.

WATER IN NAMIBIA IS VULNERABLE AND SCARCE. MOST PEOPLE USE GROUNDWATER FOR THEIR EVERYDAY ACTIVITIES. WITH THE CURRENT CLIMATIC CONDITIONS WATER TABLES ARE DROPPING AND DAMS ARE DRYING UP FAST. THE GROWING POPULATION AND ECONOMIC ACTIVITIES INCREASES THE DEMAND FOR WATER COUNTRY WIDE. SUSTAINABLE DEVELOPMENT, WATER USE EFFICIENCY AND DEMAND MANAGEMENT MUST BE EMPLOYED TO ENSURE ENOUGH SUPPLY, ALSO FOR THE FUTURE GENERATION.

IT IS UP TO ALL NAMIBIANS, YOUNG AND OLD, TO PROTECT OUR SCARCE WATER RESOURCES. TO BE ABLE TO MANAGE IT, ONE MUST FIRST KNOW AND UNDERSTAND ITS NATURE. OUR MOST UTILIZED RESOURCE, THE GROUNDWATER, IS TO MANY OF US A MIRACLE. DIGGING OR DRILLING A HOLE IN THE GROUND CAN PROVIDE US WITH THIS VALUABLE ELEMENT. BUT HOW DOES IT COME THERE? HOW MUCH CAN BE PUMPED? IS IT SAFE TO DRINK? WHAT CAN I DO TO PROTECT IT FROM OVER ABSTRACTION AND CONTAMINATION?

WORLDWIDE IT IS RECOGNIZED THAT IT IS IMPERATIVE THAT YOUTH PARTICIPATE ACTIVELY IN ALL RELEVANT LEVELS OF DECISION-MAKING PROCESSES, RECOGNIZING THEIR INTELLECTUAL CONTRIBUTION, ABILITY TO MOBILIZE SUPPORT, AND UNIQUE PERSPECTIVES. FOR NAMIBIA THE THOUGHT IS TRUER AND THIS IS ONLY POSSIBLE IF THE YOUTH AND YOUNG PEOPLE ARE PROVIDED WITH OPPORTUNITIES AND RELEVANT INFORMATION ON WATER RESOURCES, ITS NATURE, USE AND MANAGEMENT.

IN THIS SCIENCE BASED COMIC BOOK, THE HEROES, SAM, TULI AND H₂O, PROVIDE THE ANSWER TO THE QUESTIONS POSED ABOVE. AS THE FUTURE ADULTS, THESE YOUNG PEOPLE, ARE GIVEN INFORMATION, TO ACTIVELY INFORM AND PARTICIPATE IN DEVELOPING THE FUTURE AGENDA, TOWARDS SECURING ACCESS TO WATER FOR ALL. THE MINISTRY OF AGRICULTURE, WATER AND FORESTRY DEVELOPED IT IN COOPERATION WITH ITS PARTNER, THE FEDERAL INSTITUTE FOR GEOSCIENCE AND NATURAL RESOURCES OF GERMANY (BGR) TO GIVE YOUNG LEARNERS AND THOSE THAT ARE YOUNG AT HEART A FUN WAY TO UNDERSTAND NAMIBIA'S HIDDEN TREASURE, THE GROUNDWATER! HAPPY LEARNING!

DEPUTY PERMANENT SECRETARY
MINISTRY OF AGRICULTURE, WATER AND FORESTRY
MR ABRAHAM NEHEMIA



FOREWORD

NATURAL RESOURCES ARE NAMIBIA'S GREATEST ASSET. UNIQUE LANDSCAPES, WILDLIFE, A DIVERSE FLORA AND MINERAL COMMODITIES ARE THE BACKBONE OF THE COUNTRY'S ECONOMY. ONE RESOURCE IS HOWEVER SCARCE AS NOWHERE ELSE IN SUB-SAHARAN AFRICA: WATER.

ALL SOCIAL AND ECONOMIC DEVELOPMENTS ARE CHALLENGED WITHOUT SECURE ACCESS TO GOOD QUALITY WATER. SINCE INDEPENDENCE IT IS GERMANY'S AIM TO SUPPORT NAMIBIA'S EFFORTS IN IMPROVING SUSTAINABLE MANAGEMENT STRATEGIES WITH A SPECIAL FOCUS ON THE PRECIOUS GROUNDWATER RESERVOIRS.

IN THE FRAME OF THE CURRENT JOINT PROJECT "GROUNDWATER MANAGEMENT IN THE NORTH OF NAMIBIA" IMPLEMENTED BY THE NAMIBIAN MINISTRY OF AGRICULTURE, WATER AND FORESTRY (MAWF) AND THE GERMAN FEDERAL INSTITUTE FOR GEOSCIENCE AND NATURAL RESOURCES (BGR) A HUGE GROUNDWATER BODY, THE SO-CALLED OHANGWENA-II-AQUIFER, WAS DISCOVERED.

THIS AQUIFER HAS THE POTENTIAL TO ATTENUATE THE WATER SHORTAGE IN WIDE PARTS OF NORTHERN NAMIBIA. IT REQUIRES HOWEVER A JOINT EFFORT IN ORDER TO SECURE AND PROTECT THIS STRATEGIC RESOURCE. HOW IT CAN BE DONE IS TOLD IN THIS COMIC, WHICH WAS DEVELOPED THROUGH A NAMIBIAN-GERMAN TEAM OF GEO-EXPERTS AND ARTISTS. WITH THIS KNOWLEDGE, THE FUTURE GENERATIONS WILL BE ABLE TO SAFEGUARD THEIR BASIS FOR LIVELIHOOD.

AMBASSADOR OF THE FEDERAL REPUBLIC OF GERMANY IN NAMIBIA
CHRISTIAN MATTHIAS SCHLAGA



Embassy of the Federal
Republic of Germany
Windhoek



H₂O

H₂O IS A HELPFUL, ADVENTUROUS CHARACTER WHO CAN TRANSFORM INTO ANY SHAPE AND MULTIPLY INTO MANY DIFFERENT CHARACTERS... THE SAME, YET DIFFERENT. HE APPEARS AS IF BY 'MAGIC' WHEN EITHER SAM OR TULI CALL HIM...BUT ...ONLY THEY CAN SEE AND HEAR HIM.



TULI

TULI IS VERY CLEVER AND IS ALWAYS STUDYING. SHE'S A BOOKWORM. SAM IS HER BEST FRIEND AND CONFIDENT, THEY ARE IN THE SAME CLASS AT SCHOOL. TULI IS NOT AS BRAVE AS SAM, BUT SHE ADMIRES HIS COURAGE AND DETERMINATION TO PUT THINGS RIGHT AND IS ALWAYS READY TO HELP HIM. SHE IS LEARNING TO LOVE NATURE THROUGH SAM'S PASSION, AND IN PARTICULAR THE NATURAL PROCESSES THAT MAKE OUR WORLD HABITABLE.



SAM

SAM IS AN OPTIMISTIC, CHEERFUL CHARACTER, A NATURE LOVER, WHOSE PRIMARY CONCERN IS FOR THE ENVIRONMENT... A YOUNG ECO WARRIOR! HE LOVES THE OUTDOORS AND WILLINGLY CHAMPIONS ANY CAUSE THAT HE FEELS WILL BENEFIT THE ENVIRONMENT. TULI IS HIS BEST FRIEND AND HE KNOWS SHE IS VERY CLEVER AND OFTEN ASK HER ABOUT LIFE AROUND HIM. IF SHE DOESN'T KNOW THE ANSWER, THEY GO TO MR. SMART.



MR SMART

MR. SMART IS SAM AND TULI'S SCHOOL SCIENCE TEACHER. THE CHILDREN GO TO HIM FOR HELP SOMETIMES. HE IS KIND AND WISE AND ALWAYS WILLING AND EAGER TO HELP THEM UNDERSTAND WHAT IS NEEDED TO MAKE A SITUATION RIGHT.



DR ROCK

DR ROCK IS A HYDROGEOLOGIST WORKING IN THE CUVELAI-ETOSHA BASIN AREA. SHE KNOWS MR SMART AND OFTEN VISITS THE SCHOOL TO TEACH THE KIDS ABOUT GROUND WATER AND WATER PROTECTION.



MR KEMANYA

MR KEMANYA IS A HYDROGEOLOGIST ALSO WORKING IN THE CUVELAI-ETOSHA BASIN AREA. HIS LOVE FOR JOKES, HIS LOCAL KNOWLEDGE OF THE AREA AND LOVE FOR HIS WORK MAKES HIM A GREAT FRIEND TO HAVE.

KEY POINTS IN THE WATER CYCLE

EVAPORATION

THE TRANSFORMATION OF WATER FROM LIQUID TO GAS PHASES AS IT MOVES FROM THE GROUND OR BODIES OF WATER INTO THE OVERLYING ATMOSPHERE. THE SOURCE OF ENERGY FOR EVAPORATION IS PRIMARILY SOLAR RADIATION. EVAPORATION OFTEN IMPLICITLY INCLUDES TRANSPIRATION FROM PLANTS, THOUGH TOGETHER THEY ARE SPECIFICALLY REFERRED TO AS EVAPOTRANSPIRATION.

TRANSPIRATION

THE RELEASE OF WATER VAPOR FROM PLANTS AND SOIL INTO THE AIR. WATER VAPOR IS A GAS THAT CANNOT BE SEEN.

EVAPOTRANSPIRATION

COMBINED SUM OF EVAPORATION AND TRANSPIRATION

CONDENSATION

THE TRANSFORMATION OF WATER VAPOR TO LIQUID WATER DROPLETS IN THE AIR, CREATING CLOUDS AND FOG.

PRECIPITATION

CONDENSED WATER VAPOR THAT FALLS TO THE EARTH'S SURFACE . MOST PRECIPITATION OCCURS AS RAIN, BUT ALSO INCLUDES SNOW, HAIL, FOG DRIP, GRAUPEL, AND SLEET.

RUNOFF

THE VARIETY OF WAYS BY WHICH WATER MOVES ACROSS THE LAND. THIS INCLUDES BOTH SURFACE RUNOFF AND CHANNEL RUNOFF. AS IT FLOWS, THE WATER MAY SEEP INTO THE GROUND, EVAPORATE INTO THE AIR, BECOME STORED IN LAKES OR RESERVOIRS, OR BE EXTRACTED FOR AGRICULTURAL OR OTHER HUMAN USES.

INFILTRATION

THE FLOW OF WATER FROM THE GROUND SURFACE INTO THE GROUND. ONCE INFILTRATED, THE WATER BECOMES SOIL MOISTURE OR GROUNDWATER.

SUBSURFACE FLOW

THE FLOW OF WATER UNDERGROUND, IN THE VADOSE ZONE AND AQUIFERS. SUBSURFACE WATER MAY RETURN TO THE SURFACE (E.G. AS A SPRING OR BY BEING PUMPED) OR EVENTUALLY SEEP INTO THE OCEANS. WATER RETURNS TO THE LAND SURFACE AT LOWER ELEVATION THAN WHERE IT INFILTRATED, UNDER THE FORCE OF GRAVITY OR GRAVITY INDUCED PRESSURES. GROUNDWATER TENDS TO MOVE SLOWLY, AND IS REPLENISHED SLOWLY, SO IT CAN REMAIN IN AQUIFERS FOR THOUSANDS OF YEARS.

ADVECTION

THE MOVEMENT OF WATER – IN SOLID, LIQUID, OR VAPOR STATES – THROUGH THE ATMOSPHERE. WITHOUT ADVECTION, WATER THAT EVAPORATED OVER THE OCEANS COULD NOT PRECIPITATE OVER LAND.

ENDORHEIC RIVERS

ENDORHEIC DRAINAGE BASINS ARE INLAND BASINS THAT DO NOT DRAIN TO AN OCEAN. EXAMPLES ARE THE ETOSHA SALT PAN AND THE OKAVANGO DELTA IN BOTSWANA



OH ...I THINK IN SCIENCE CLASS MR. SMART TOLD US ABOUT THAT...

IT EVAPORATED SAM...

YES...REMEMBER, WATER IS TWO PARTS HYDROGEN AND ONE PART OXYGEN.



YOU CALLED!

H₂O?

THAT'S ME... YOU WERE TALKING ABOUT EVAPORATION?

I WAS....

LET ME EXPLAIN ... EVAPORATION IS A PART, OF A MUCH BIGGER PROCESS, CALLED **THE WATER CYCLE**. DURING THE WATER CYCLE, WATER COULD APPEAR AS ...



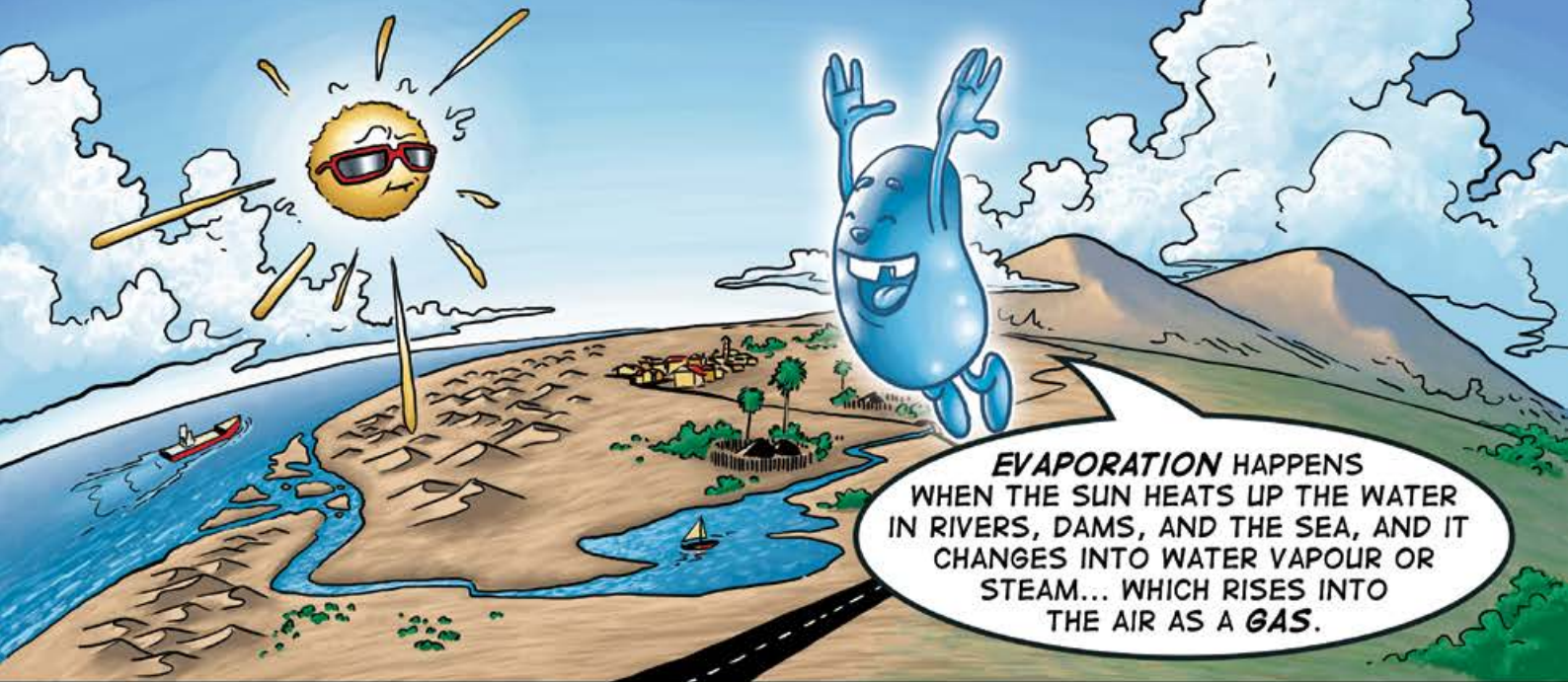
A LIQUID, **WATER**...




A SOLID, **ICE**...



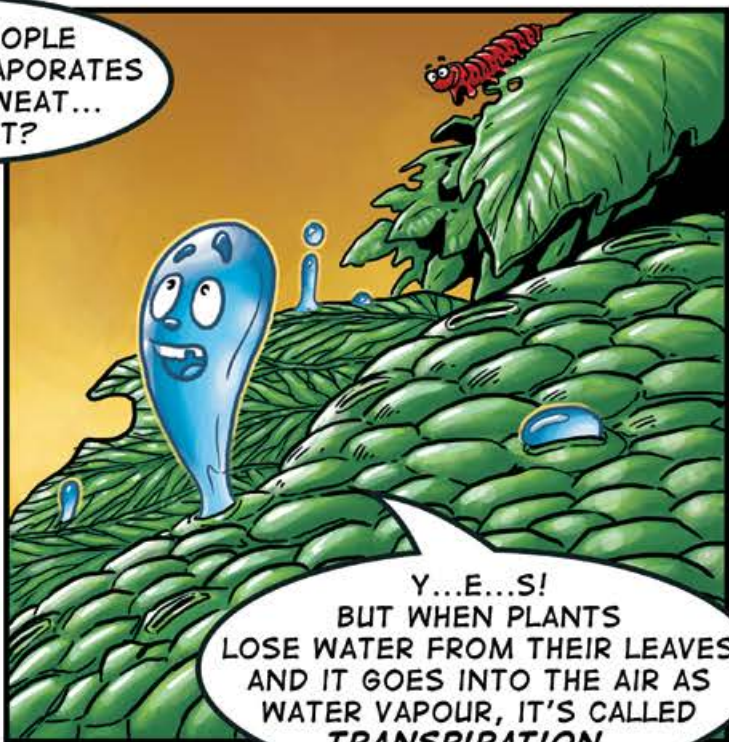
OR A GAS, **VAPOUR**.



EVAPORATION HAPPENS WHEN THE SUN HEATS UP THE WATER IN RIVERS, DAMS, AND THE SEA, AND IT CHANGES INTO WATER VAPOUR OR STEAM... WHICH RISES INTO THE AIR AS A **GAS**.



WATER IN PEOPLE AND PLANTS EVAPORATES WHEN THEY SWEAT... DOESN'T IT?



Y...E...S!
BUT WHEN PLANTS LOSE WATER FROM THEIR LEAVES AND IT GOES INTO THE AIR AS WATER VAPOUR, IT'S CALLED **TRANSPIRATION**.

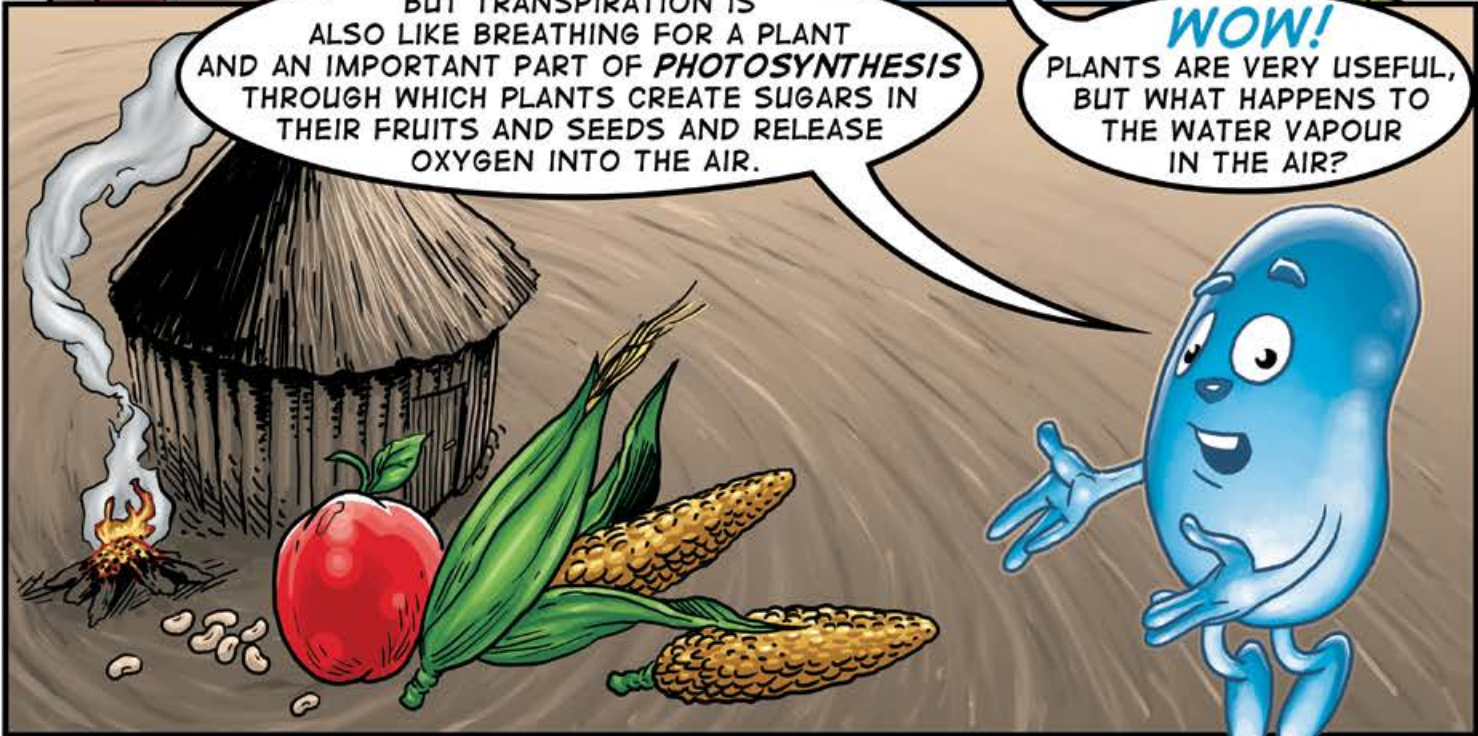
SO DO PLANTS ONLY TRANSPIRE WHEN IT IS REALLY HOT?

WELL SAM, MORE **TRANSPIRATION** HAPPENS WHEN IT IS HOT TO HELP COOL THE PLANTS, MUCH LIKE OUR SWEAT,

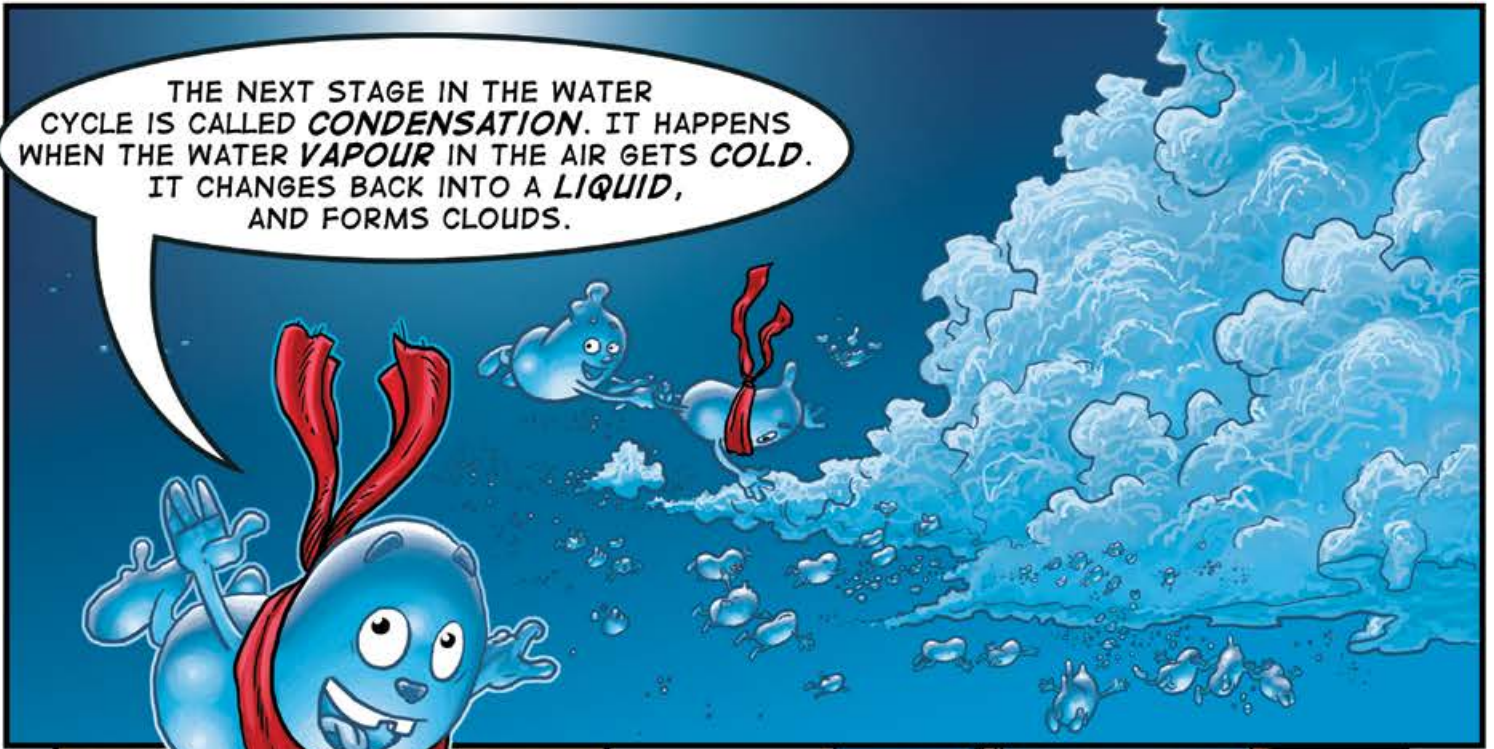


BUT TRANSPIRATION IS ALSO LIKE BREATHING FOR A PLANT AND AN IMPORTANT PART OF **PHOTOSYNTHESIS** THROUGH WHICH PLANTS CREATE SUGARS IN THEIR FRUITS AND SEEDS AND RELEASE OXYGEN INTO THE AIR.

WOW!
PLANTS ARE VERY USEFUL, BUT WHAT HAPPENS TO THE WATER VAPOUR IN THE AIR?



THE NEXT STAGE IN THE WATER CYCLE IS CALLED **CONDENSATION**. IT HAPPENS WHEN THE WATER **VAPOUR** IN THE AIR GETS **COLD**. IT CHANGES BACK INTO A **LIQUID**, AND FORMS CLOUDS.



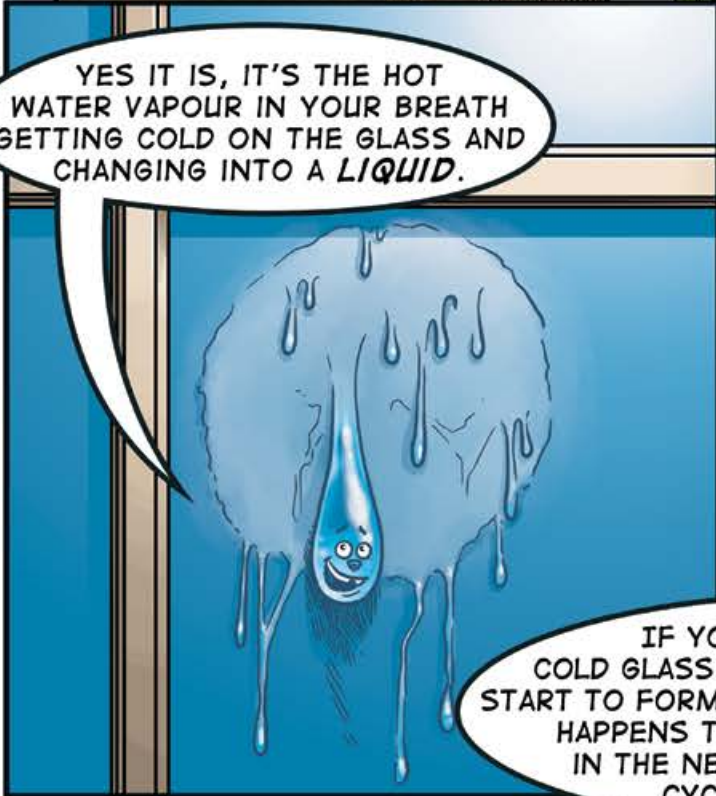
SOMETIMES YOU SEE **CLOUDS** APPEAR FROM NOWHERE IN A CLEAR BLUE SKY.



...IN WINTER, AT NIGHT WHEN IT'S REALLY COLD, IF YOU BREATHE ON GLASS IT GETS ALL MISTED UP... IS THAT **CONDENSATION** TOO?



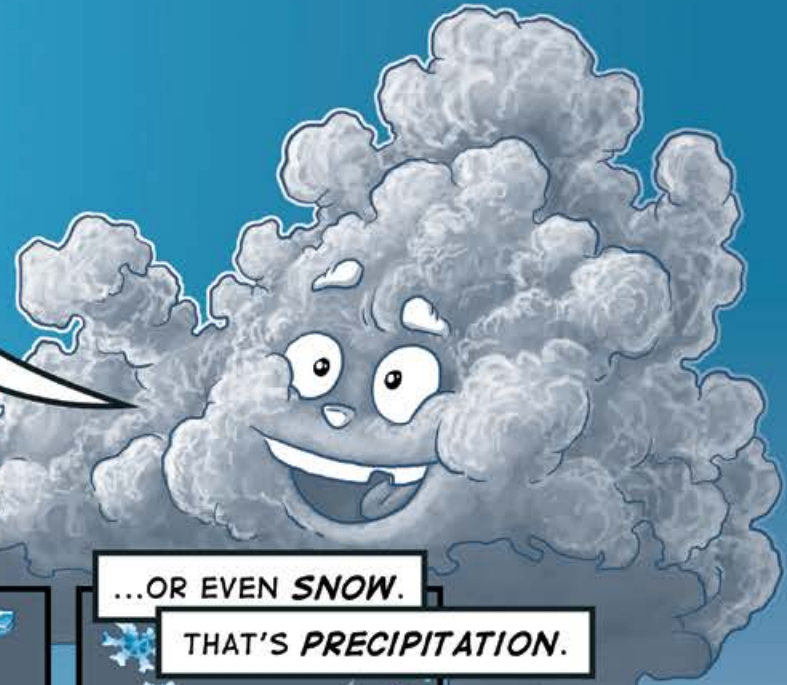
YES IT IS, IT'S THE HOT WATER VAPOUR IN YOUR BREATH GETTING COLD ON THE GLASS AND CHANGING INTO A **LIQUID**.



IF YOU BREATHE ON THE COLD GLASS A LOT, TRICKLES OF WATER START TO FORM AND RUN DOWN, THAT'S WHAT HAPPENS TO THE WATER IN THE SKY, IN THE NEXT STAGE OF THE WATER CYCLE, **PRECIPITATION**.



IT HAPPENS
WHEN A LOT OF WATER
CONDENSES; THE AIR CAN'T HOLD
IT ANYMORE AND THE CLOUDS GET
SO HEAVY THAT THE WATER
FALLS BACK DOWN TO
EARTH...



...AS **RAIN**,



... **HAIL**,



...OR EVEN **SNOW**.

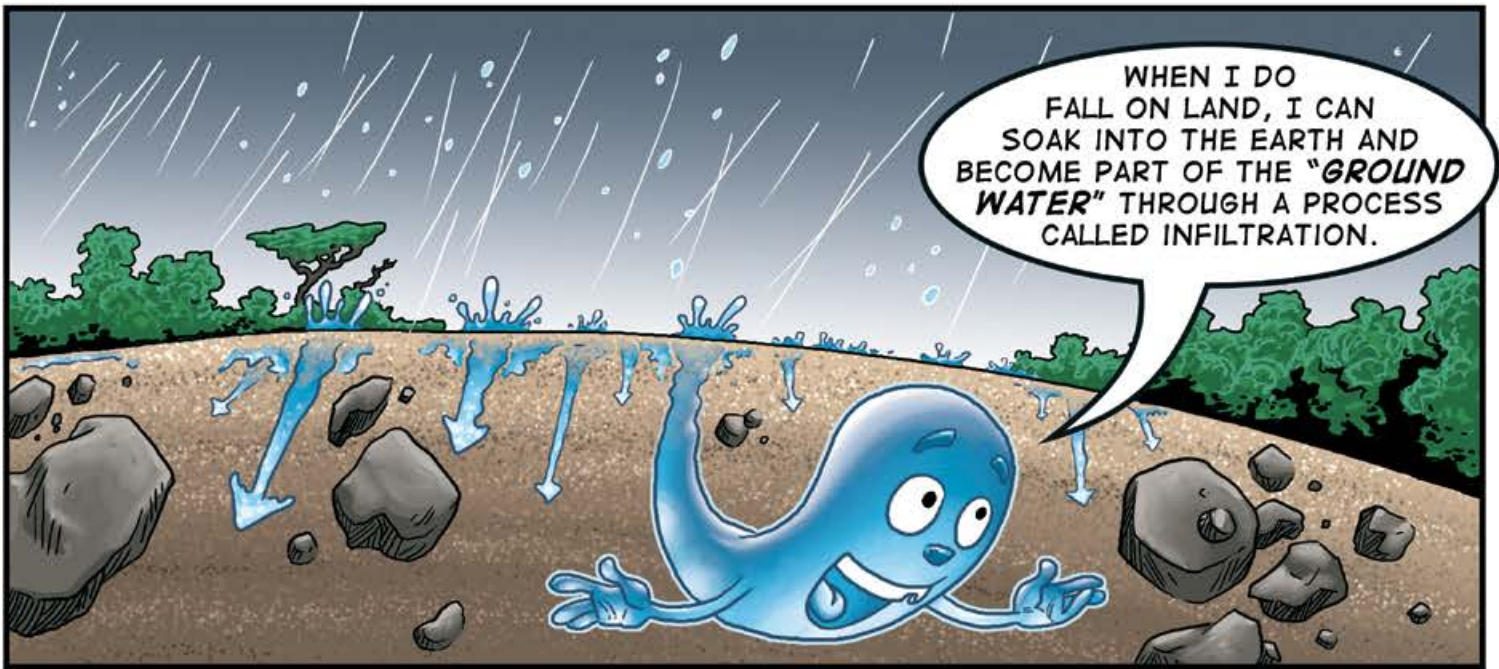


THAT'S **PRECIPITATION**.

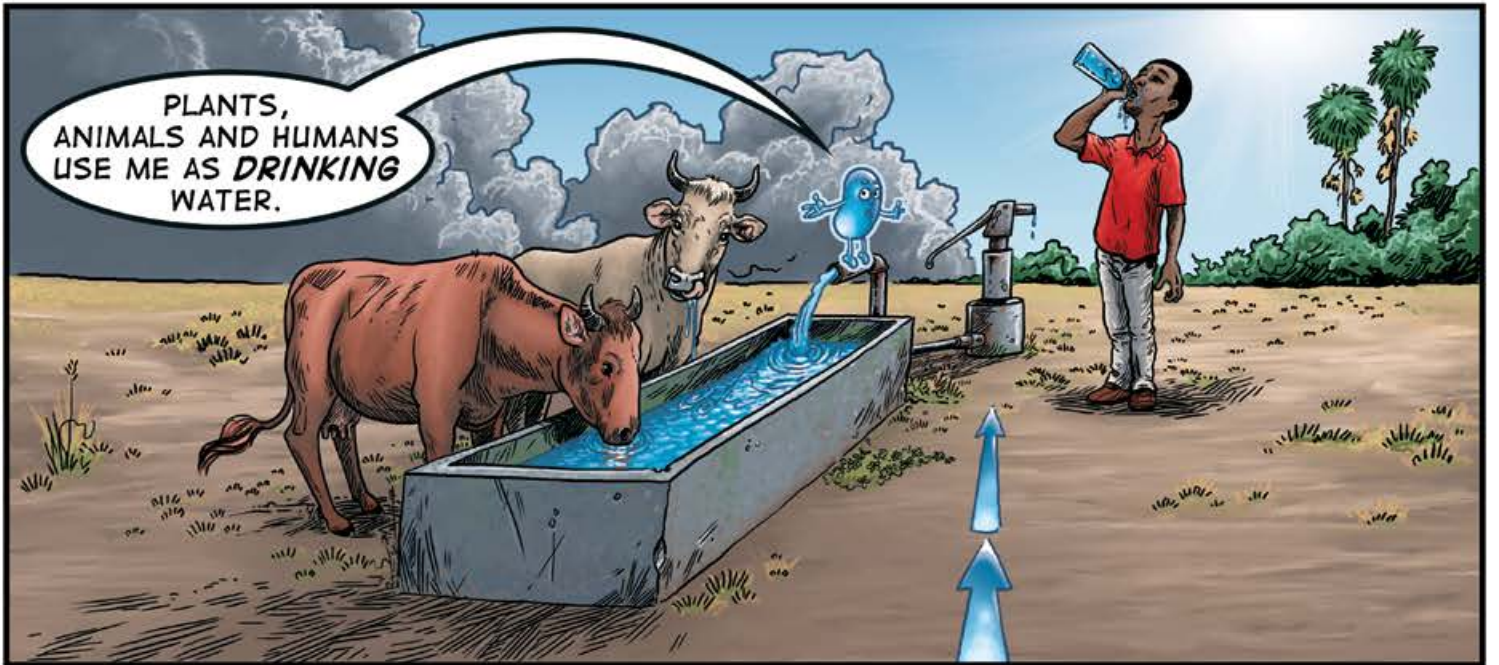
I HEARD THAT
IN THE WINTER IT
SOMETIMES **SNOWS**
IN THE DESERT!



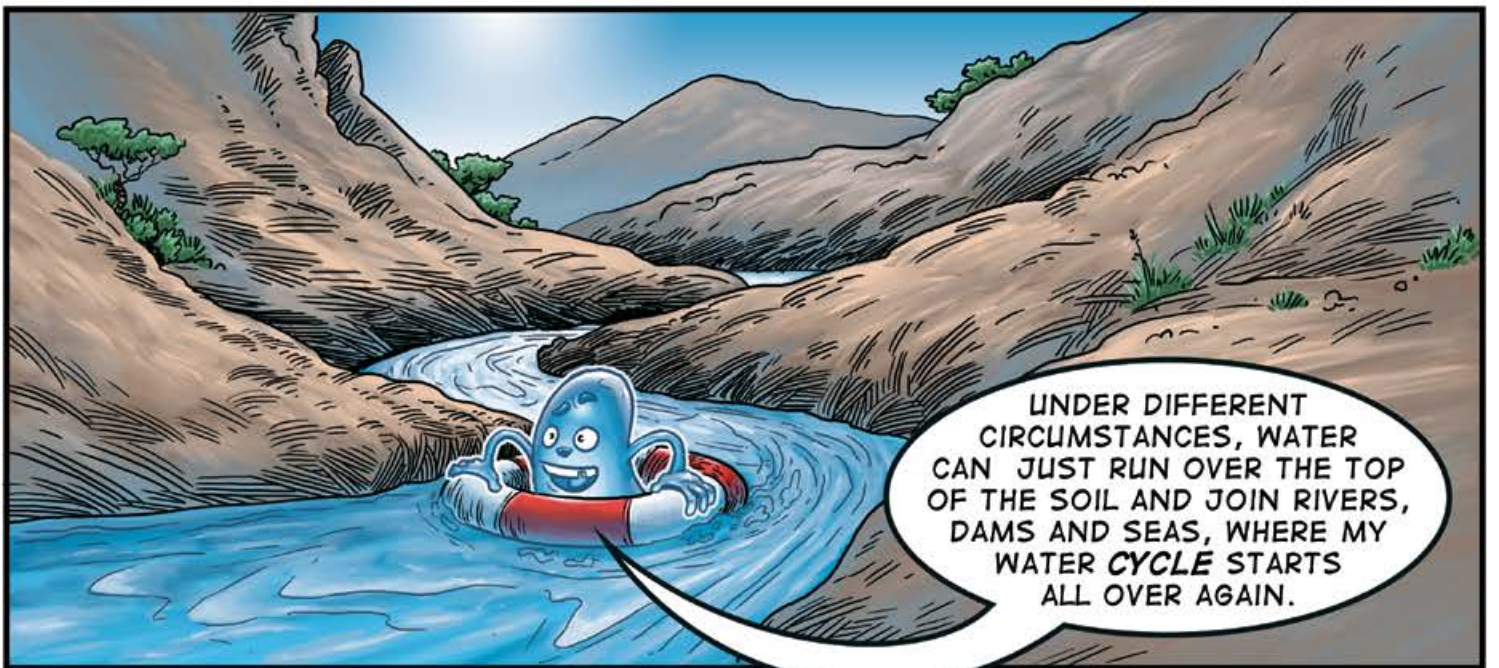
WATER CAN FALL BACK
TO EARTH ANYWHERE, IN THE SEA,
DAMS AND RIVERS AND ON LAND,
EVEN IN THE DESERT!



WHEN I DO FALL ON LAND, I CAN SOAK INTO THE EARTH AND BECOME PART OF THE "GROUND WATER" THROUGH A PROCESS CALLED INFILTRATION.



PLANTS, ANIMALS AND HUMANS USE ME AS DRINKING WATER.

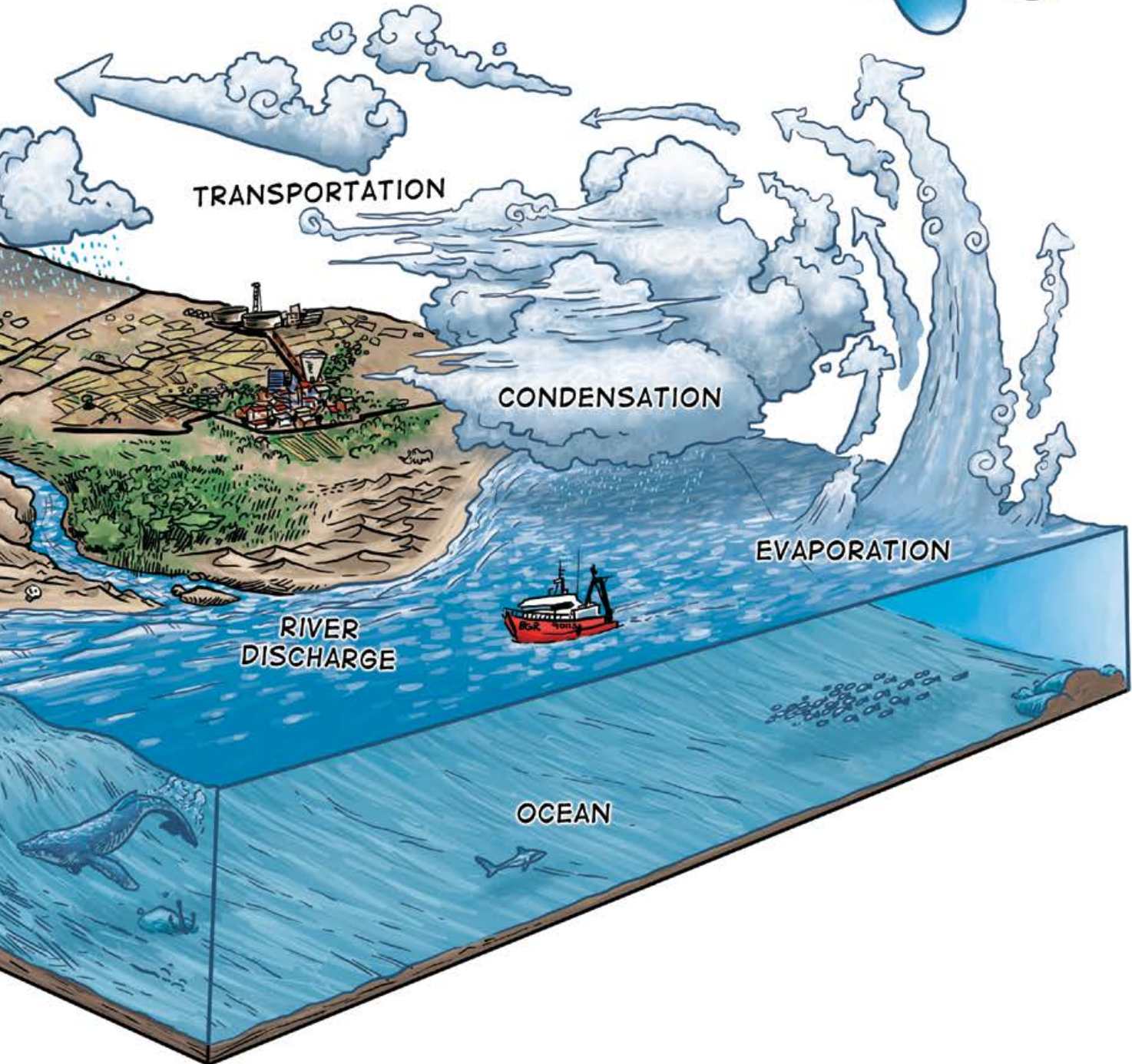
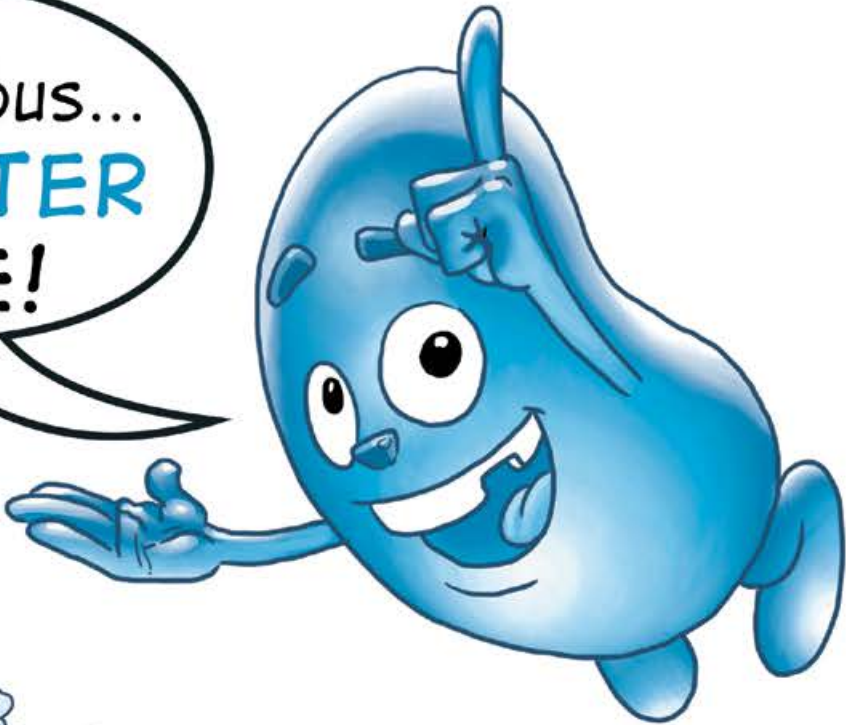


UNDER DIFFERENT CIRCUMSTANCES, WATER CAN JUST RUN OVER THE TOP OF THE SOIL AND JOIN RIVERS, DAMS AND SEAS, WHERE MY WATER CYCLE STARTS ALL OVER AGAIN.

WOW...
THAT'S AWESOME!



IT IS,
I'M PRECIOUS...
**BE WATER
WISE!**



KEY POINTS IN GROUND WATER

AQUIFER

AN AQUIFER IS AN UNDERGROUND LAYER OF WATER-BEARING PERMEABLE ROCK, ROCK FRACTURES OR UNCONSOLIDATED MATERIALS (GRAVEL, SAND, OR SILT) FROM WHICH GROUNDWATER CAN BE EXTRACTED USING A WATER WELL.

BOREHOLE

A DEEP, NARROW HOLE MADE IN THE GROUND, ESPECIALLY TO LOCATE WATER OR OIL.

CASING

CASING IS LARGE DIAMETER PIPE THAT IS ASSEMBLED AND INSERTED INTO A RECENTLY DRILLED SECTION OF A BOREHOLE AND TYPICALLY HELD INTO PLACE WITH CEMENT.

CONTAMINATE

MAKE SOMETHING IMPURE BY EXPOSURE TO OR ADDITION OF A POISONOUS OR POLLUTING SUBSTANCE.

DRILLING RIG

A DRILLING RIG IS A MACHINE THAT CREATES HOLES IN THE EARTH SUB-SURFACE. DRILLING RIGS CAN BE MASSIVE STRUCTURES HOUSING EQUIPMENT USED TO DRILL WATER WELLS, OIL WELLS, OR NATURAL GAS EXTRACTION WELLS.

DRILL BIT

DRILL BITS ARE CUTTING TOOLS USED TO CREATE CYLINDRICAL HOLES, ALMOST ALWAYS OF CIRCULAR CROSS-SECTION. DRILL BITS COME IN MANY SIZES AND HAVE MANY USES. BITS ARE USUALLY CONNECTED TO A MECHANISM, OFTEN SIMPLY REFERRED TO AS A DRILL, WHICH ROTATES THEM AND PROVIDES TORQUE AND AXIAL FORCE TO CREATE THE HOLE.

HYDROGEOLOGIST

A HYDROGEOLOGIST IS A PERSON WHO STUDIES THE WAYS THAT GROUNDWATER (HYDRO) MOVES THROUGH THE SOIL AND ROCK OF THE EARTH (GEOLOGY). A SIMILAR PROFESSION, A HYDROLOGIST, IS SOMEONE WHO STUDIES SURFACE WATER.

OPEN CANAL

AN OPEN CANAL, CHANNEL, OR DITCH, IS AN OPEN WATERWAY WHOSE PURPOSE IS TO CARRY WATER FROM ONE PLACE TO ANOTHER.

PH VALUE

THE PH SCALE MEASURES HOW ACIDIC OR BASIC A SUBSTANCE IS. IT RANGES FROM 0 TO 14. A PH OF 7 IS NEUTRAL. A PH LESS THAN 7 IS ACIDIC, AND A PH GREATER THAN 7 IS BASIC.

PIPELINE

PIPELINE TRANSPORT IS THE TRANSPORTATION OF GOODS OR MATERIAL THROUGH A PIPE, NORMALLY WATER OR GAS.

POLLUTE

TO MAKE DIRTY, FOUL OR UNCLEAN, ESPECIALLY WITH HARMFUL CHEMICAL OR WASTE PRODUCTS.

PROTECTION ZONE

AN AREA AROUND A SPECIFIC POINT, LIKE A BOREHOLE, WHERE CERTAIN ACTIVITIES, OBJECTS, CHEMICALS OR POSSIBLE DANGEROUS SUBSTANCES SHOULD NOT BE ALLOWED.

THE OHANGWENA REGION IN NORTHERN *NAMIBIA* ...

HEY *SAM*,
ARE YOU READY FOR
SCHOOL?

OH HEY *TULI*,
YEAH LET'S GO





MR SMART! DID YOU SEE THE TRUCKS AND MACHINES AND PEOPLE WITH THE JACKETS?

TULI SAYS THEY'RE DRILLERS, BUT WHY WOULD ANYONE WANT TO...

SLOW DOWN!! SEEMS YOU'RE WAY AHEAD OF ME TODAY. IT HAS TO DO WITH **GROUNDWATER**, BUT GET SETTLED DOWN AND WE CAN DISCUSS IT WITH THE REST OF THE CLASS.

ONCE EVERYONE HAS SETTLED DOWN, MR SMART BEGINS...

MORNING CLASS...

AS SOME OF YOU MIGHT HAVE SEEN ON YOUR WAY TO SCHOOL, A DRILLING COMPANY IS SETTING UP TO DRILL A NEW **BOREHOLE**.

THE PEOPLE WHO DECIDED TO DRILL THERE ARE CALLED **HYDROGEOLOGISTS**...

H₂O?!

PLIP





HEY TULI!!
HEY SAM!!

...BUT
...WE DIDN'T CALL
YOU...



NO?
BUT I HEARD MY
NAME...
AT LEAST I HEARD
"HYDRO"...

DOES
ANYONE KNOW WHAT A
HY-DRO-GE-OLO-GIST
DOES?

Hydrogeologist



DO THEY DRILL
FOR **WATER**?

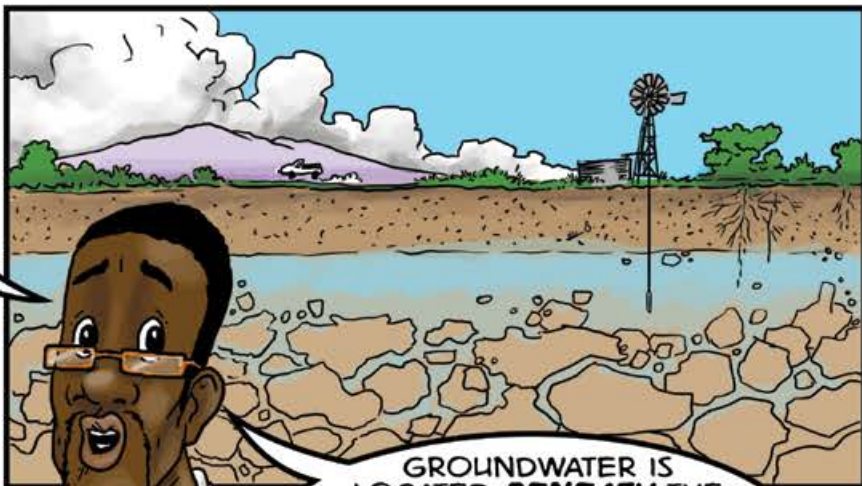


EXACTLY!!
HYDRO- MEANING
WATER, AND -GEOLOGY
MEANING THE STUDY OF THE
EARTH, DEALS WITH THE
DISTRIBUTION AND MOVEMENT
OF **GROUNDWATER** IN THE
SOIL AND ROCKS OF THE
EARTH'S CRUST.

THESE WATER-BEARING
LAYERS ARE CALLED
AQUIFERS.



THERE IS FAR MORE **FRESH WATER** STORED UNDERGROUND THAN THERE IS IN **ALL** THE WORLD'S LAKES AND RIVERS.



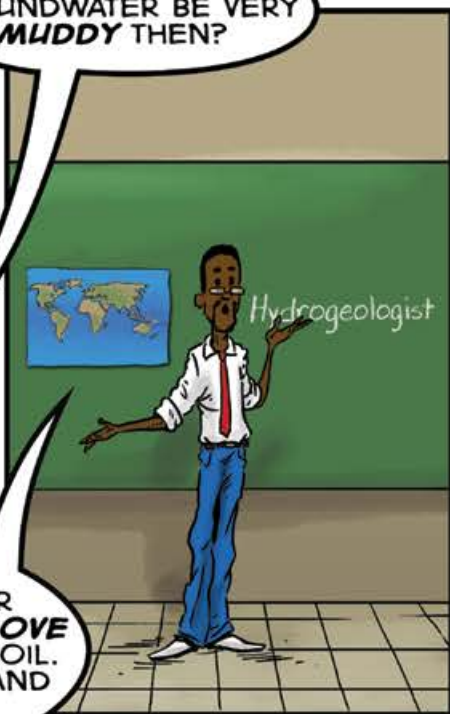
GROUNDWATER IS LOCATED **BENEATH** THE EARTH'S SURFACE, WHEREVER THERE ARE PORES AND CRACKS IN THE SOIL AND ROCKS.

WHEN **PRECIPITATION**, LIKE RAIN, SEEPS DOWN INTO THE GROUND, IT BECOMES PART OF THE GROUNDWATER.



WOULDN'T GROUNDWATER BE VERY **MUDDY** THEN?

ACTUALLY, TO INFILTRATE THE WATER TABLE, WATER HAS TO **MOVE** THROUGH ROCKS AND SOIL. THEY ACT AS A FILTER AND **REMOVES** LARGE PARTICLES.

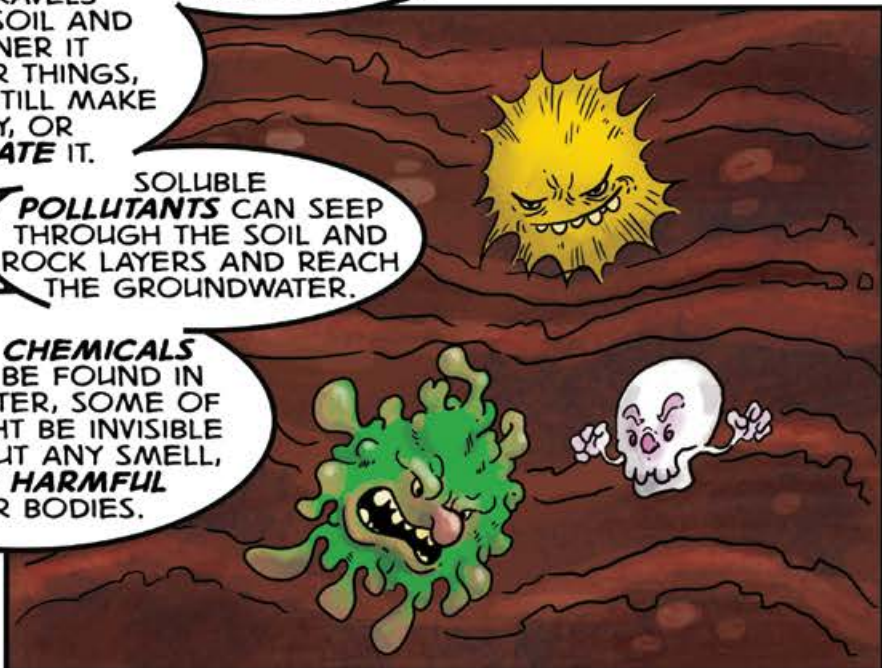


THE FURTHER THE WATER TRAVELS THROUGH THE SOIL AND ROCKS, THE CLEANER IT WILL GET. OTHER THINGS, HOWEVER, CAN STILL MAKE THE WATER DIRTY, OR **CONTAMINATE** IT.



SOLUBLE **POLLUTANTS** CAN SEEP THROUGH THE SOIL AND ROCK LAYERS AND REACH THE GROUNDWATER.

NATURAL CHEMICALS CAN ALSO BE FOUND IN GROUNDWATER, SOME OF WHICH MIGHT BE INVISIBLE AND WITHOUT ANY SMELL, BUT ARE **HARMFUL** TO OUR BODIES.





THIS IS WHY THE WATER NEEDS TO BE **TESTED** BEFORE IT CAN BE USED.

THERE ARE ALSO SOME NATURAL CHEMICALS THAT ARE **NOT** DANGEROUS TO OUR HEALTH, BUT MAY CAUSE THE WATER TO **SMELL** FUNNY OR EVEN HAVE A DIFFERENT COLOUR.



I HAVE TRAVELLED THROUGH MANY **AQUIFERS**.

WHEN THE PORES AND CRACKS ARE LARGE, I FLOW THROUGH **EASILY**




SOMETIMES I HAVE TO **SQUEEEEEEZE** THROUGH VERY TIGHT SPACES.


IT MIGHT EVEN TAKE YEARS TO TRAVEL A SHORT DISTANCE!



MR SMART, *HOW* DOES THE DRILLING RIG WORK?



WELL SAM, THE WELLS THEY DRILL ARE VERY MUCH *LIKE* THE **HAND DUG** WELLS WE USUALLY USE FOR FRESH WATER, BUT THEY ARE *MUCH* DEEPER.



*THESE WELLS ARE USUALLY FITTED WITH A PIPE, CALLED A CASING, AND A SCREEN. THE WATER SEEPS THROUGH THE SCREEN, INTO THE CASING, WHICH THEN FILLS WITH GROUNDWATER. THE WATER CAN THEN BE BROUGHT TO THE **SURFACE** BY A PUMP.




BUT HOW DO THEY KNOW *WHERE* TO DRILL?

AHA, THAT IS THE PART **DR ROCK**, ONE OF THE HYDROGEOLOGISTS THAT ARE WORKING ON-SITE, WILL EXPLAIN TO YOU TOMORROW.



IN SHORT KIDS, I **TRAVEL THROUGH** PERMEABLE LAYERS OF SOIL TO REACH AQUIFERS WHERE GROUNDWATER IS STORED.



HAND DUG WELLS ARE MORE LIKELY TO DRY UP, BUT DRILLED BOREHOLES CAN REACH FAR **DEEPER** INTO THE AQUIFERS, SUPPLYING YOU WITH WATER ALL YEAR ROUND.

* ... SEE PAGE 20 FOR FULL DIAGRAM

... AFTER SCHOOL ...

HEY H_2O , CAN WE RUN OUT OF GROUNDWATER?

YES, BUT ONLY IF **MORE** WATER IS USED THAN CAN BE RECHARGED.

I THINK I UNDERSTAND!

SO THE **SUPPLY** IS **NOT ENDLESS**, AND MUCH LIKE DRINKING WATER THROUGH A STRAW, IT RUNS OUT IF YOU **DON'T FILL UP YOUR GLASS?**

YES! AND THE MORE **WELLS** THERE ARE, THE MORE STRAWS ARE IN YOUR GLASS! **ADDING** STRAWS DOES NOT ADD WATER AND THEREFORE, ONLY CAUSES THE WATER TO RUN OUT **SOONER**.

OH NO!! BUT WOULDN'T THAT MEAN THAT THE DRILLING RIG WILL CAUSE US TO RUN OUT OF WATER?

NO! MANY OF THE WELLS, LIKE THE ONE YOU SAW, ARE INSTALLED TO OBSERVE RATHER THAN INCREASE USAGE.

HYDROGEOLOGISTS NEED TO **STUDY** A WATER SOURCE THOROUGHLY TO KNOW HOW MUCH WATER CAN BE TAKEN **WITHOUT** USING IT UP.

THEY ALSO NEED TO **OBSERVE** THE QUALITY OF THE WATER, TO KNOW IF IT IS SAFE TO DRINK. THIS IS WHY THE OBSERVATION BOREHOLES SHOULD **NOT** BE USED OR DAMAGED! THEY ARE **IMPORTANT** AND WE ALL NEED TO SAFEGUARD THEM!

SO THE HYDROGEOLOGISTS MAKE SURE WE **DON'T** DRINK THE WATER IF IT CAN MAKE US SICK AND DON'T USE TOO MUCH FROM **ONE** SOURCE?

YES! THEY PROTECT ME AND YOU AS BEST THEY CAN.

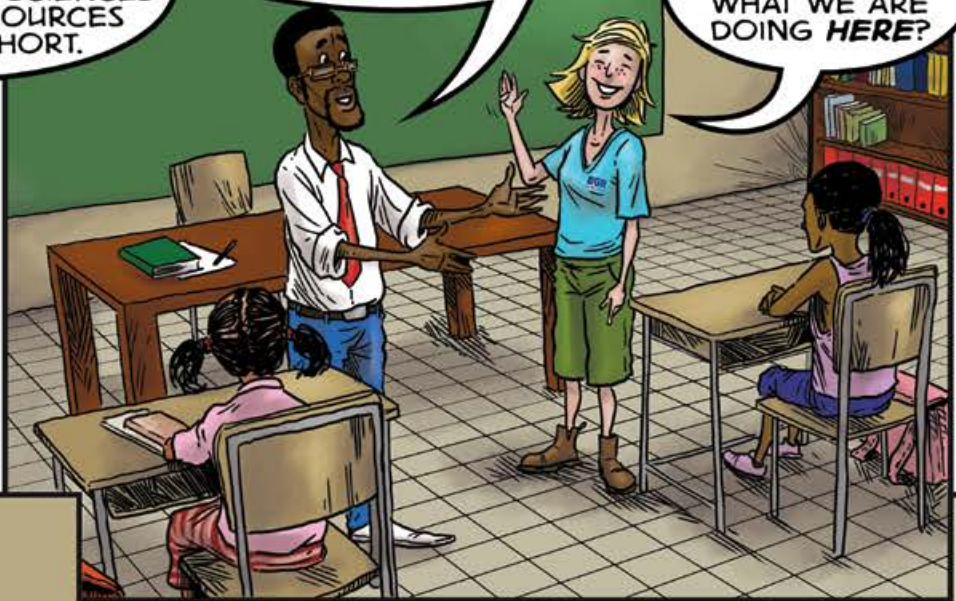


THE NEXT DAY...

GOOD MORNING CLASS, WE HAVE A **VISITOR** TODAY FROM THE FEDERAL INSTITUTE FOR GEOSCIENCES AND NATURAL RESOURCES OR, BGR FOR SHORT.

DR ROCK IS ONE OF THEIR **HYDROGEOLOGIST** AND HELPS AT THE DRILLING RIG WE TALKED ABOUT YESTERDAY. SHE WILL HELP US UNDERSTAND THE WHY'S AND HOW'S OF **DRILLING** FOR WATER.

HELLO CLASS. I HEAR A FEW OF YOU ARE VERY **CURIOUS** ABOUT WHAT WE ARE DOING **HERE?**



YES!



BEFORE WE DECIDE ON A SPOT TO **DRILL** WE DO A LOT OF INVESTIGATING. IN THIS CASE, WE STARTED WITH A HELICOPTER USING VERY COOL MACHINES, TO SEE WHAT LIES **BENEATH** THE **GROUND**.

THE INFORMATION WE **GATHER** FROM THIS HELPS US TO IDENTIFY AREAS THAT ARE WORTH TAKING A CLOSER LOOK AT.

NEXT, WE DO **GROUND-LEVEL** INVESTIGATIONS OVER THE AREAS THAT OUR AIRBORNE SEARCHES HAVE IDENTIFIED.

HERE WE CHOOSE POINTS WHERE WE SCAN THE UNDERGROUND - MUCH LIKE A DOCTOR'S X-RAY OF YOUR BONES, BUT MUCH COOLER!



WE ALSO INVESTIGATED EXISTING BOREHOLES IN THE AREA AND TOOK SAMPLES TO TEST THE QUALITY.





IN **NORTHERN** NAMIBIA, A LOT OF WATER COMES FROM THE **KUNENE RIVER** - ALL THE WAY FROM **ANGOLA** THROUGH AN OPEN CANAL. IT IS THEN DISTRIBUTED THROUGH **PIPELINES**.

IN OTHER AREAS, THE **MAIN** WATER SUPPLY SOURCES ARE **WELLS** AND **BOREHOLES**.

WOW!!! YOU MEAN YOU HAVE CROSSED BORDERS AND TRAVELLED HUNDREDS OF KILOMETRES TO GET **HERE**?



ANGOLA

NAMIBIA



EVEN MORE!! WITH HELP FROM THE SUN, WIND, WEATHER CHANGE, GRAVITY AND WATER PRESSURE I HAVE TRAVELLED AROUND THE **WORLD** MILLIONS OF TIMES!!



NO WONDER WE NEED TO BE WATER WISE! YOU'VE LIVED THAT LONG AND TRAVELLED THAT FAR TO MAKE SURE ALL LIVING THINGS CAN SURVIVE!! **YOU CERTAINLY ARE PRECIOUS!!!**



BUT DR ROCK!!! WHEN DO YOU START **DRILLING**???

HAHAHA RIGHT NOW!! WITH ALL THE INFORMATION WE HAVE GATHERED WE KNOW WHERE TO DRILL, HOW DEEP WE HAVE TO DRILL, WHAT KIND OF ROCKS WE WILL DRILL THROUGH AND WHAT WATER QUALITY TO EXPECT.

CAN WE START **USING** THE WATER THEN?

THE DRILLING WE ARE CURRENTLY DOING IS TO **MONITOR** THE GROUNDWATER. THE EXISTING BOREHOLES PUMP WATER FROM THE SAME SOURCE.



REMEMBER WHAT **H₂O** SAID ABOUT THE STRAWS?

WHEN NEW SOURCES ARE FOUND HOWEVER, THE NEWLY DRILLED HOLES ARE FITTED WITH A PUMP AND A WELLHEAD FOR **PROTECTION**. THE WATER IS THEN **DISTRIBUTED** TO **HUMANS** AND **ANIMALS**.

SOME OF THE NEWER BOREHOLES HAVE **FENCES** AROUND THEM, IS THAT ALSO FOR PROTECTION?



YES, WE ARE SETTING UP **PROTECTION ZONES**, SO NO ANIMALS OR HUMANS CAN **CONTAMINATE** OR **DAMAGE** THE BOREHOLE!!



CAN YOU TELL US DR ROCK, WHAT **EXACTLY** DO YOU **MONITOR** AT THE WELLS YOU DRILL, AND WHY?



OF COURSE, WE WERE STILL BUSY WITH THAT!

WELL, BY **MONITORING** THE WATER LEVEL AT BOREHOLES, WE HAVE A VERY GOOD IDEA OF **WHERE** WATER IS FLOWING ...

...AND IF THE RAIN IS **RECHARGING** THE SOURCE OR NOT.

WATER SAMPLES FROM BOREHOLES CAN ALSO TELL US IF THE WATER IS **AFFECTED** BY HUMANS AND ANIMALS, MAYBE THROUGH CATTLE DROPPINGS OR OTHER BACTERIA.

BUT WHAT DO YOU DO WITH THE **INFORMATION** DR ROCK?



WHY DON'T YOU ALL **COME AND SEE...**

THE NEXT DAY, NOT FAR FROM THE SCHOOL ...

WE ARE GOING TO VISIT A FEW **DIFFERENT** WELLS AND TAKE **SAMPLES** OF THE WATER. THEN WE WILL ANALYSE THESE SAMPLES AND I WILL SHOW YOU HOW WE USE THESE **RESULTS**.

I CAN'T WAIT TO SEE WHAT WE CAN **LEARN** ABOUT THIS WELL TULI, I LIKE THE WORK **HYDROGEOLOGISTS** DO.

HEY GUYS! SO FEW PEOPLE ACTUALLY KNOW HOW **IMPORTANT** THIS WORK IS SAM.

HERE, TAKE A CLOSER LOOK AT THAT **WATER** FOR EXAMPLE...

EEUW!!!!
WHAT ARE THOSE???

THOSE ARE **BACTERIA** FROM COW DROPPINGS.

THE SOIL IN THIS AREA IS VERY **PERMEABLE**, WHICH MEANS THERE ARE A LOT OF **SPACES** BETWEEN THE SOIL PARTICLES.

THIS MAKES IT EASY FOR OTHER **PARTICLES** TO TRAVEL **THROUGH** THE SOIL TO THE WATER.



BUT YOU SAID THE SOIL ACTS AS A **FILTER** AND THAT THOSE THINGS CAN'T GET TO THE WATER.

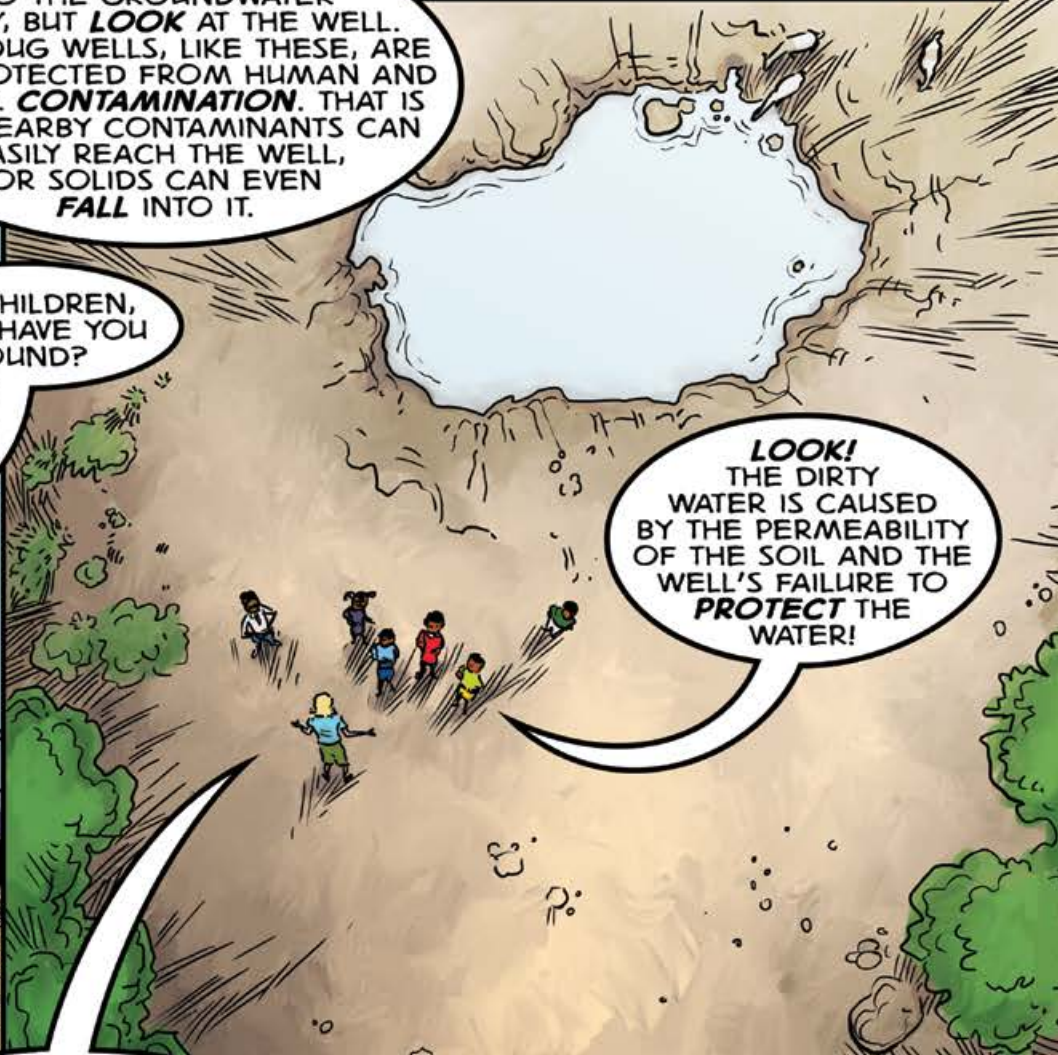


IT CAN'T GET TO THE GROUNDWATER EASILY, BUT **LOOK** AT THE WELL. HAND-DUG WELLS, LIKE THESE, ARE NOT PROTECTED FROM HUMAN AND ANIMAL **CONTAMINATION**. THAT IS WHY NEARBY CONTAMINANTS CAN EASILY REACH THE WELL, OR SOLIDS CAN EVEN **FALL** INTO IT.

SO, CHILDREN, WHAT HAVE YOU FOUND?



LOOK! THE DIRTY WATER IS CAUSED BY THE PERMEABILITY OF THE SOIL AND THE WELL'S FAILURE TO **PROTECT** THE WATER!

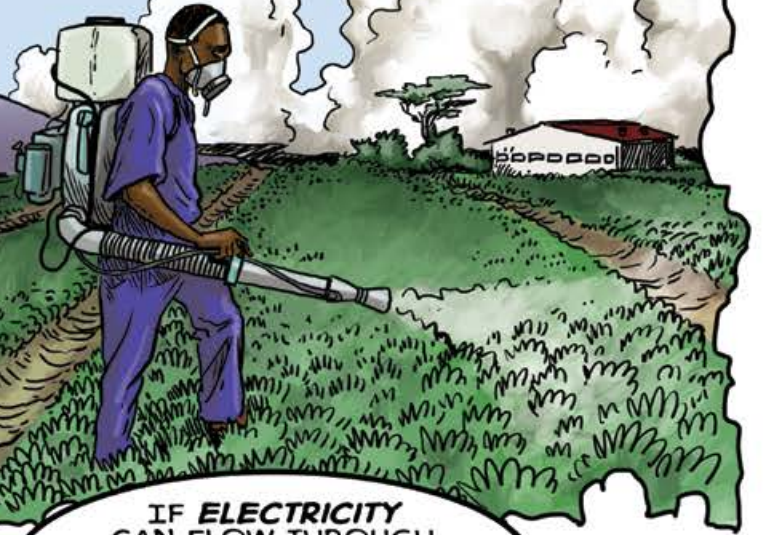
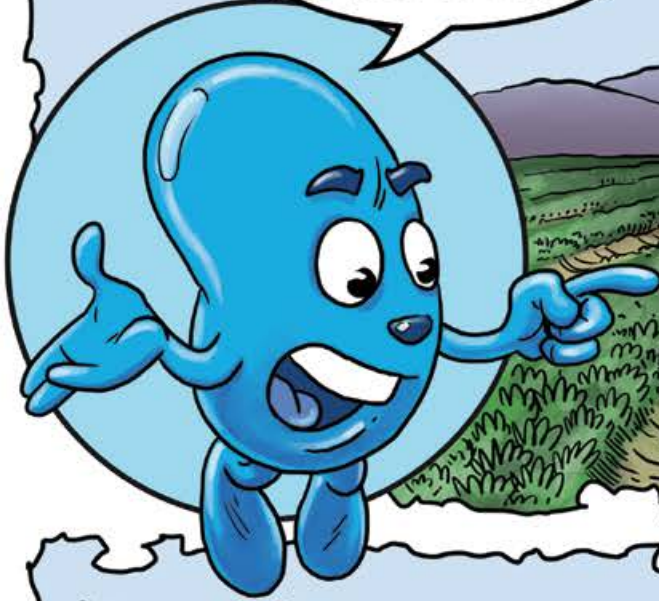


QUITE RIGHT, THIS IS EXACTLY WHAT THE **PROTECTION ZONES** AND WELLHEADS PREVENT AT THE NEWLY DRILLED HOLES!

NOW LET'S GO TO THE NEXT WELL AND I WILL SHOW YOU WHAT ELSE WE CAN FIND OUT FROM THE SAMPLES.



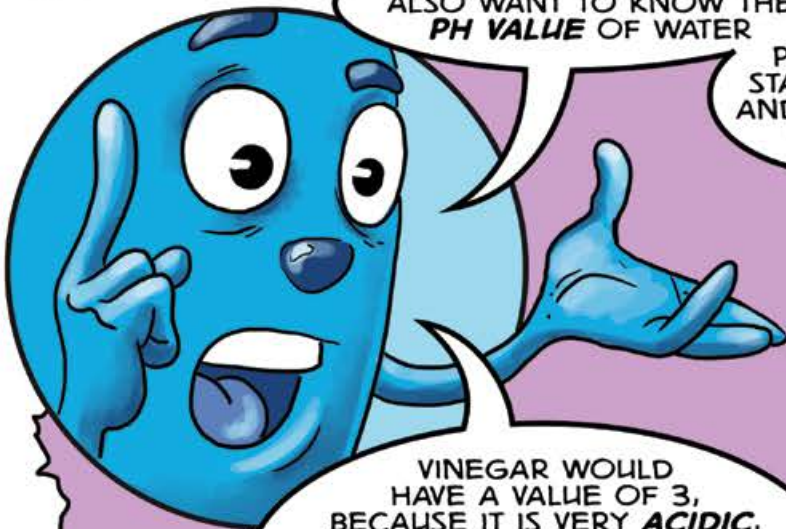
PESTICIDES
CAN CONTAMINATE
WATER OVER A LONG
PERIOD OF TIME.



IF ELECTRICITY
CAN FLOW THROUGH
WATER EASILY, IT MEANS THE
WATER CONTAINS A LOT
OF SALTS.



HYDROGEOLOGISTS
ALSO WANT TO KNOW THE
PH VALUE OF WATER



PH VALUE
STARTS AT 0
AND GOES UP
TO 14.

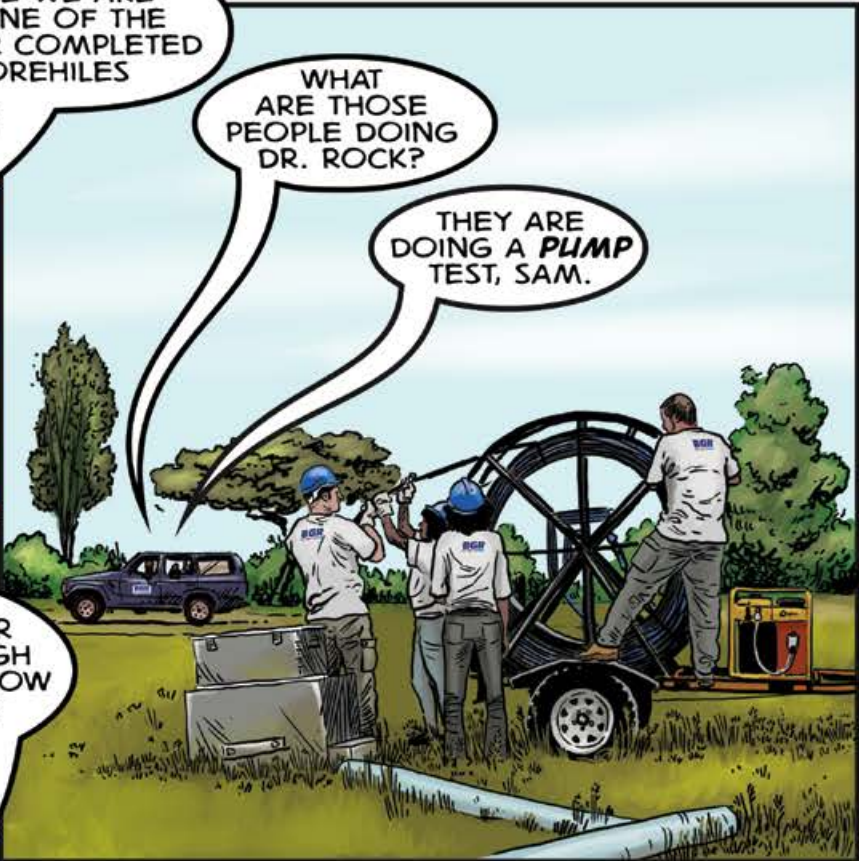
IT MEASURES
WHETHER SOMETHING
IS AN ACID OR
A BASE.

VINEGAR WOULD
HAVE A VALUE OF 3,
BECAUSE IT IS VERY **ACIDIC**.
WHILE AMMONIA CLEANER WOULD
HAVE A VALUE OF 11, BECAUSE IT IS
A STRONG **ALKALI**. PURE WATER
SHOULD BE RIGHT IN THE
MIDDLE, WITH A
VALUE OF 7.





HERE WE ARE AT ONE OF THE NEWER COMPLETED BOREHILES



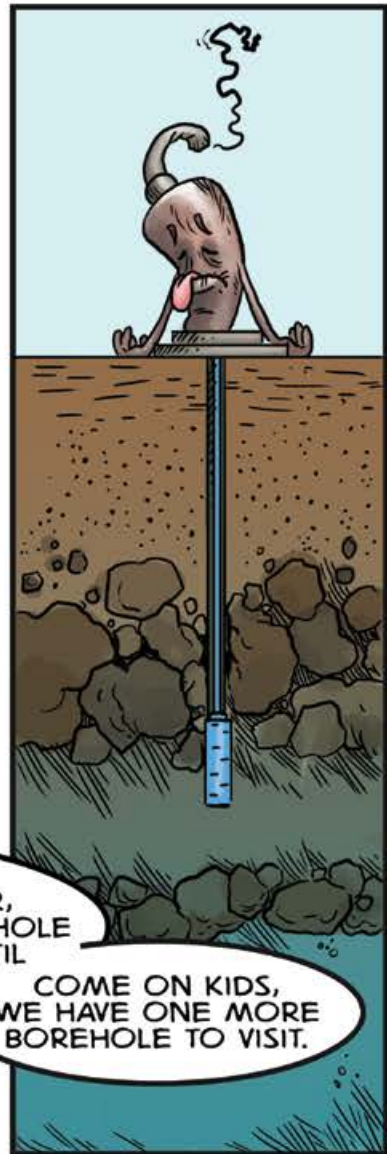
WHAT ARE THOSE PEOPLE DOING DR. ROCK?

THEY ARE DOING A **PUMP** TEST, SAM.

IT SHOWS US HOW MUCH WATER CAN **FLOW** THROUGH THE AQUIFER AND HOW MUCH WATER WE CAN TAKE OUT.

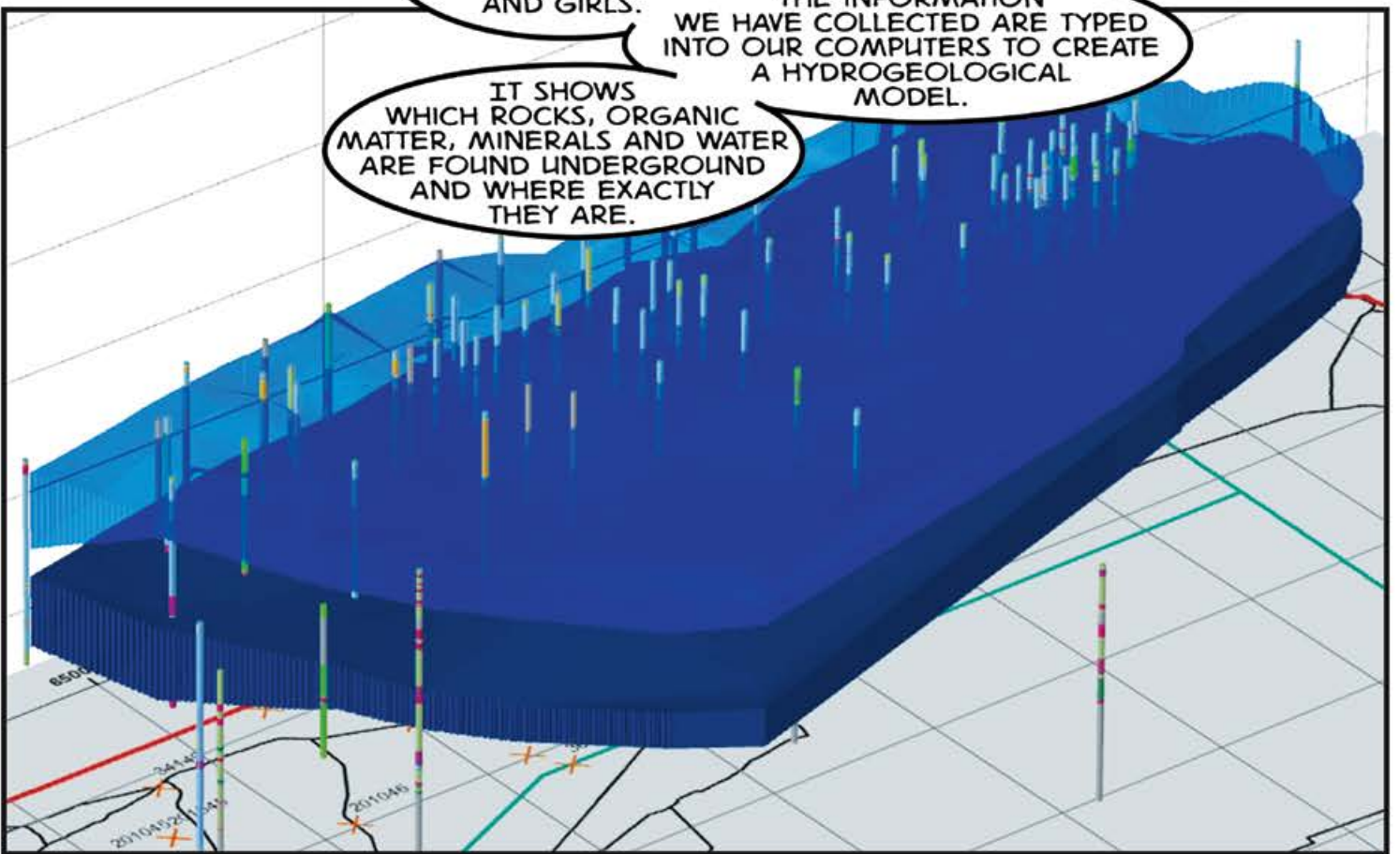
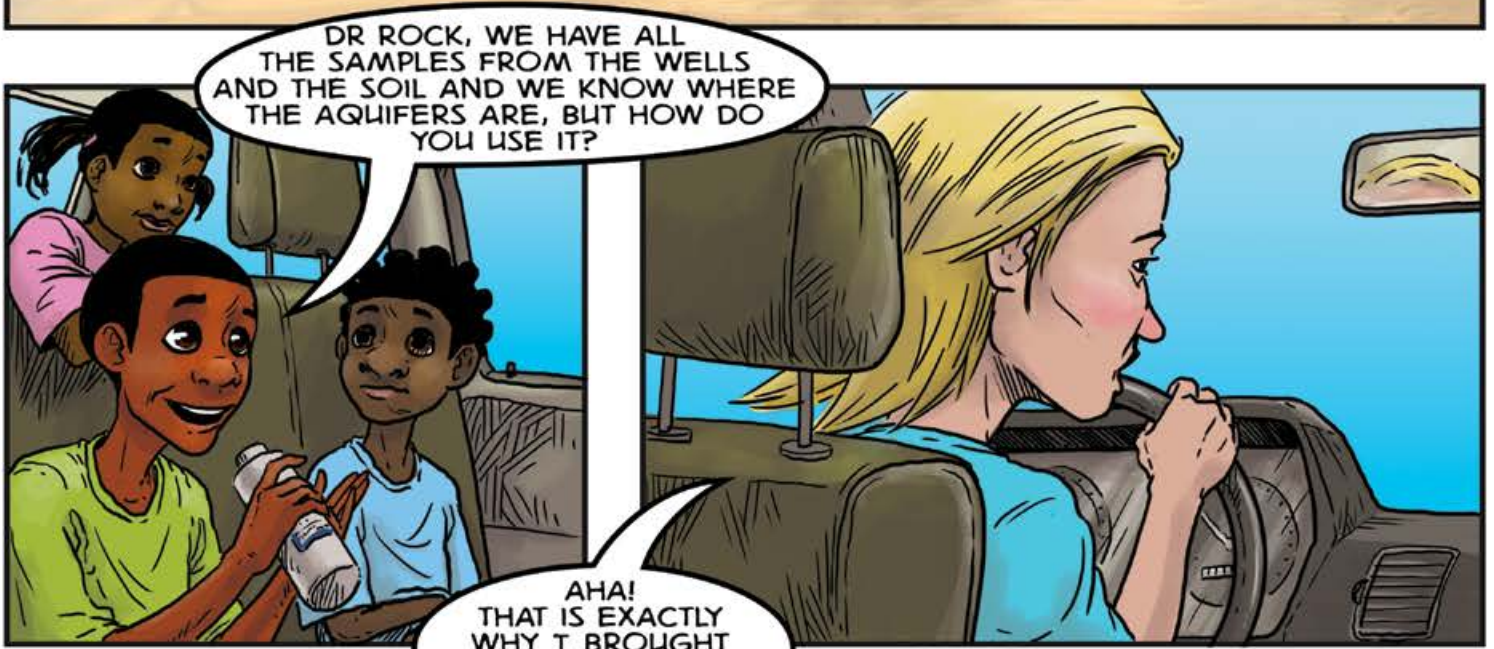


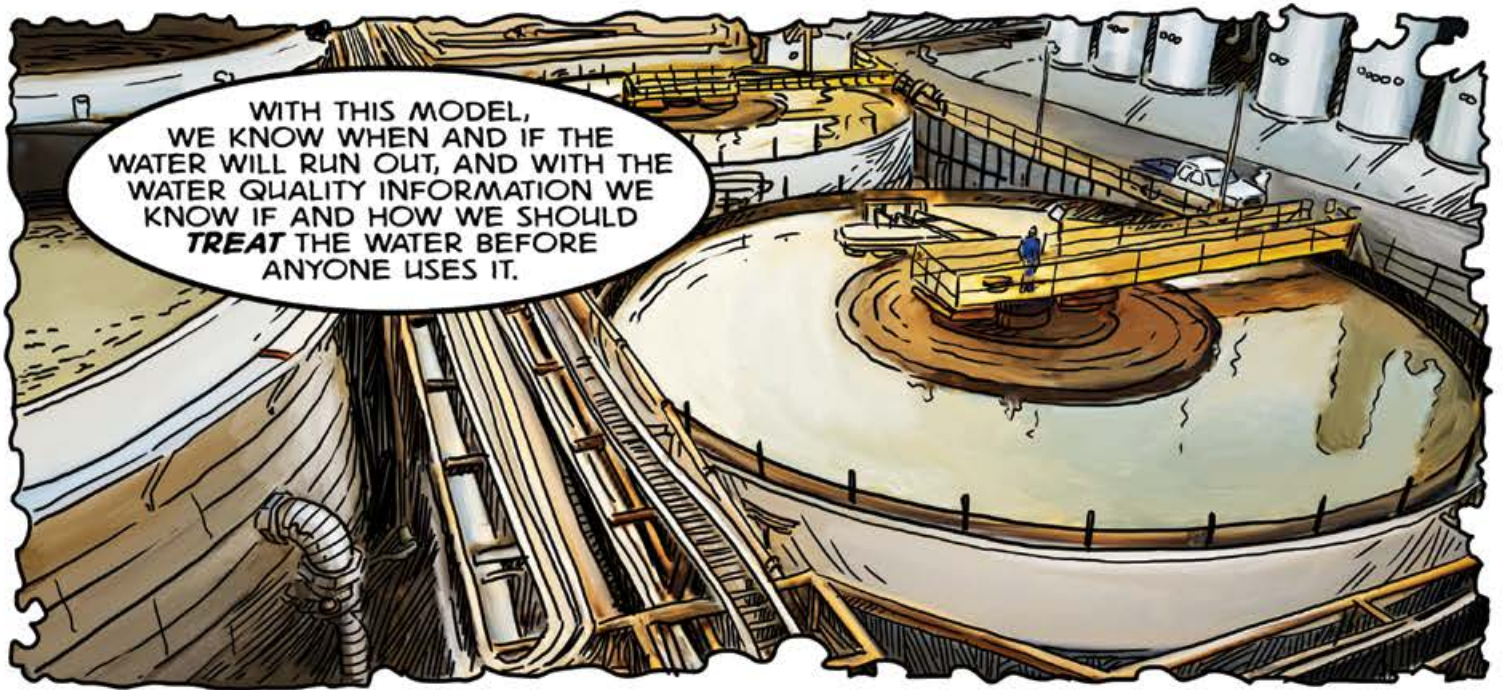
SO, THE MORE WE PUMP, THE DEEPER THE **WATER TABLE** DROPS. BUT WITH A VERY PRODUCTIVE BOREHOLE YOU CAN PUMP A LOT OF WATER WHILE THE LEVEL GOES DOWN **SLOWLY**.



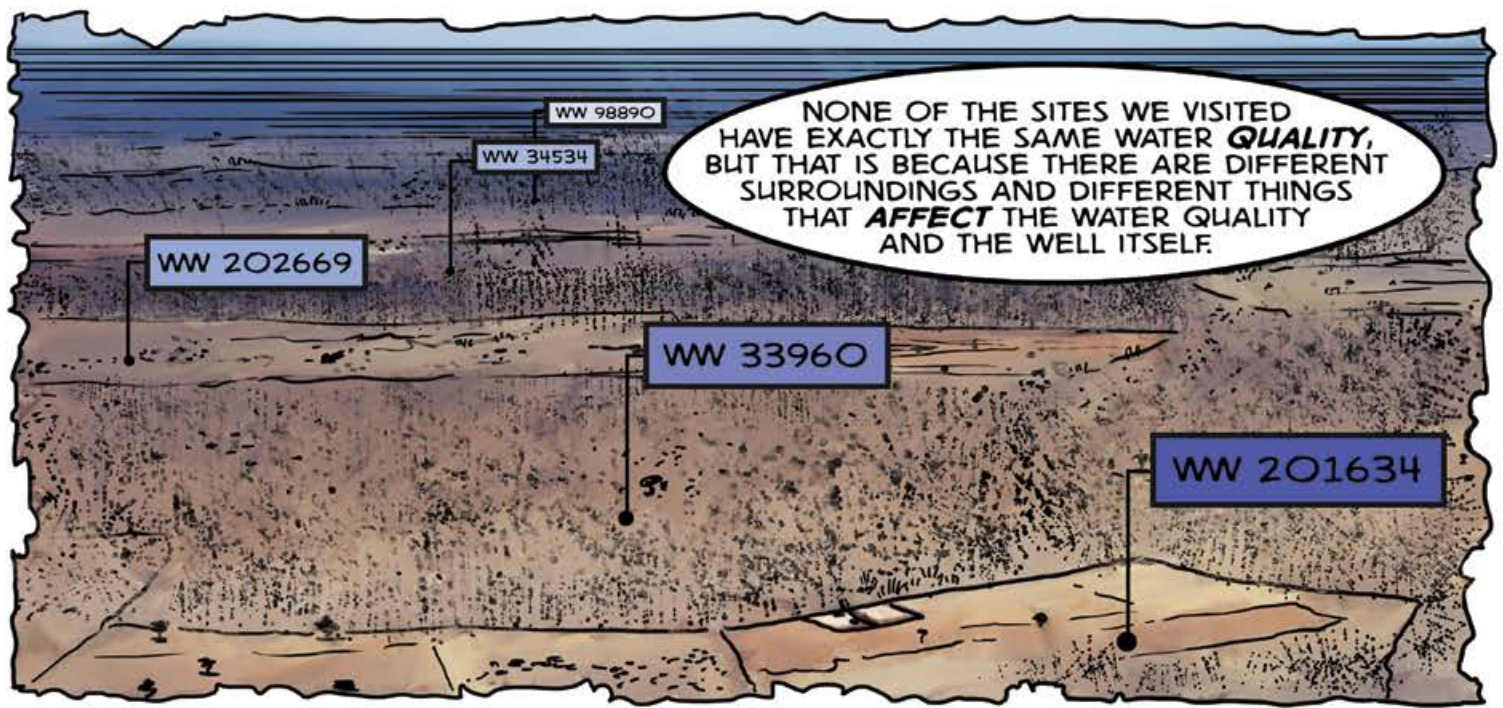
ON THE OTHER HAND, IF YOU HAVE A WEAK AQUIFER, YOU WILL EASILY PUMP THE BOREHOLE **EMPTY** AND HAVE TO WAIT UNTIL IT FILLS UP AGAIN.

COME ON KIDS, WE HAVE ONE MORE BOREHOLE TO VISIT.





WITH THIS MODEL, WE KNOW WHEN AND IF THE WATER WILL RUN OUT, AND WITH THE WATER QUALITY INFORMATION WE KNOW IF AND HOW WE SHOULD **TREAT** THE WATER BEFORE ANYONE USES IT.



NONE OF THE SITES WE VISITED HAVE EXACTLY THE SAME WATER **QUALITY**, BUT THAT IS BECAUSE THERE ARE DIFFERENT SURROUNDINGS AND DIFFERENT THINGS THAT **AFFECT** THE WATER QUALITY AND THE WELL ITSELF.



IF THESE WELLS ARE CONNECTED BY A **PIPELINE** SUPPLYING A TOWN WITH WATER AND THE WATER SOURCE IS NOT MONITORED, A WHOLE TOWN COULD SUFFER FROM ALL KINDS OF ILLNESSES.



OH LOOK,
THE DRILLING TEAM
STARTED ALREADY! NOW,
AS THE HYDROGEOLOGIST,
I HAVE TO START THE
SOIL DESCRIPTION.

IT IS VERY
IMPORTANT TO KNOW
EXACTLY HOW **DEEP**
PERMEABLE LAYERS
ARE, ...

... AND IF
AND WHERE ANY
IMPERMEABLE LAYERS
CAN BE FOUND IN OUR
BOREHOLE.



THE TEAM YOU
SEE BEHIND ME ARE
DRAWING UP DRILLING
LOGS. A **DRILLING LOG** IS
A WRITTEN **RECORD** OF THE
SOIL LAYERS THAT WE HAVE
DRILLED. SOIL SAMPLES
SHOULD BE TAKEN EVERY
METER AND DESCRIBED
IN DETAIL.



THE **LOG** WILL HELP US TO DECIDE IF WE FOUND THE RIGHT AQUIFER TO SET UP OUR WELL SCREEN, ...

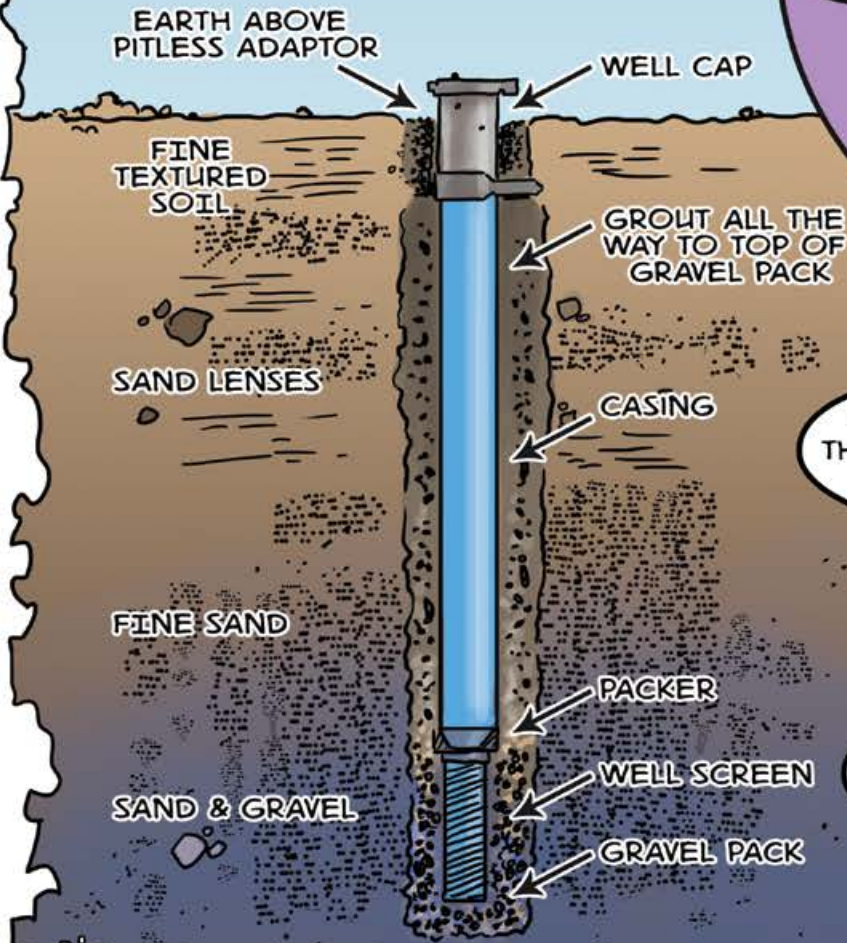
... HOW DEEP AND LONG THE **WELL SCREEN** SHOULD BE, ...

... HOW DEEP AND THICK THE **GRAVEL PACK** SHOULD BE ...



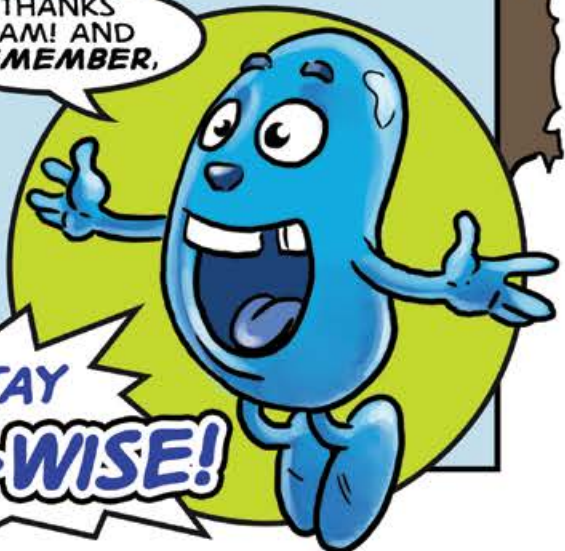
... AND WHERE EXACTLY THE **SANITARY SEAL** SHOULD BE FITTED.

I THINK I WANT TO DO THIS WHEN I AM GROWN UP, WHAT BETTER WAY TO STILL PLAY IN THE DIRT AND PROTECT OUR FRIEND **H2O** ALL-IN-ONE!!



THANKS SAM! AND REMEMBER,

STAY WATER-WISE!



KEY POINTS IN POLLUTION & CONTAMINATION

POLLUTION

POLLUTION IS THE INTRODUCTION OF CONTAMINANTS INTO THE NATURAL ENVIRONMENT THAT CAUSE ADVERSE CHANGE. POLLUTION CAN TAKE THE FORM OF CHEMICAL SUBSTANCES OR ENERGY, SUCH AS NOISE, HEAT OR LIGHT. POLLUTANTS, THE COMPONENTS OF POLLUTION, CAN BE EITHER FOREIGN SUBSTANCES/ENERGIES OR NATURALLY OCCURRING CONTAMINANTS.

CONTAMINANT

A CONTAMINANT IS ANY PHYSICAL, CHEMICAL, BIOLOGICAL OR RADIOLOGICAL SUBSTANCE OR MATTER IN WATER. DRINKING WATER MAY REASONABLY BE EXPECTED TO CONTAIN AT LEAST SMALL AMOUNTS OF SOME CONTAMINANTS. SOME CONTAMINANTS MAY BE HARMFUL IF CONSUMED AT CERTAIN LEVELS IN DRINKING WATER.

STAGNANT

WATER STAGNATION OCCURS WHEN WATER STOPS FLOWING. STAGNANT WATER CAN BE A MAJOR ENVIRONMENTAL HAZARD. STAGNANT WATER CAN BE DANGEROUS FOR DRINKING BECAUSE IT PROVIDES A BETTER INCUBATOR THAN RUNNING WATER FOR MANY KINDS OF BACTERIA AND PARASITES. STAGNANT WATER IS OFTEN CONTAMINATED WITH HUMAN AND ANIMAL FAECES, PARTICULARLY IN DESERTS OR OTHER AREAS OF LOW RAIN.

MICROORGANISM

A MICROORGANISM IS A MICROSCOPIC (TOO SMALL TO SEE WITH THE NAKED EYE) LIVING ORGANISM, WHICH MAY BE SINGLE CELLED OR MULTICELLULAR. BACTERIA AND GERMS ARE AMONG THE MANY MICROORGANISMS, SOME OF WHICH ARE HARMFUL TO HUMANS.

MONITORING

TO MONITOR OR MONITORING GENERALLY MEANS TO BE AWARE OF THE STATE OF A SYSTEM, TO OBSERVE A SITUATION FOR ANY CHANGES WHICH MAY OCCUR OVER TIME, USING A MONITOR OR MEASURING DEVICE OF SOME SORT.

ZONE

A ZONE IS AN AREA OR STRETCH OF LAND HAVING A PARTICULAR CHARACTERISTIC, PURPOSE, OR USE, OR SUBJECT TO PARTICULAR RESTRICTIONS.

PESTICIDE

A SUBSTANCE USED FOR DESTROYING INSECTS OR OTHER ORGANISMS HARMFUL TO CULTIVATED PLANTS OR TO ANIMALS.

FERTILIZER

FERTILIZERS ARE CHEMICAL OR NATURAL SUBSTANCES ADDED TO SOIL OR LAND TO INCREASE ITS FERTILITY.

INDUSTRIAL WASTAGE

INDUSTRIAL WASTE IS THE WASTE PRODUCED BY INDUSTRIAL ACTIVITY WHICH INCLUDES ANY MATERIAL THAT IS RENDERED USELESS DURING A MANUFACTURING PROCESS SUCH AS THAT OF FACTORIES, INDUSTRIES, MILLS, AND MINING OPERATIONS.

WATER PURIFICATION

WATER PURIFICATION IS THE PROCESS OF REMOVING UNDESIRABLE CHEMICALS, BIOLOGICAL CONTAMINANTS, SUSPENDED SOLIDS AND GASES FROM CONTAMINATED WATER. THE GOAL IS TO PRODUCE WATER FIT FOR A SPECIFIC PURPOSE.

POOR
UNCLE HAFENI, HE
REALLY DOESN'T SEEM
WELL AT ALL.

YEAH,
HE GOT **SICK** YESTERDAY.
MY MOM SAYS HE HAS
A STOMACH BUG!



A BUG!
HOW DID A BUG GET INTO HIS STOMACH?
DID HE EAT IT?



I DON'T KNOW,
THAT'S JUST WHAT MY
MOM SAYS, WE COULD ASK HER,
BUT LET'S GET THIS **WATER**
BACK HOME.



YOU CALLED!
AAAH, THIS IS A NICE BUCKET,
WHERE ARE YOU TAKING IT?

MY UNCLE IS
SICK AND REALLY
THIRSTY SO HE ASKED
US TO FETCH HIM
SOME WATER.

OH NO,
YOU CAN'T GIVE HIM
THIS WATER, IT WILL MAKE
HIM WORSE!



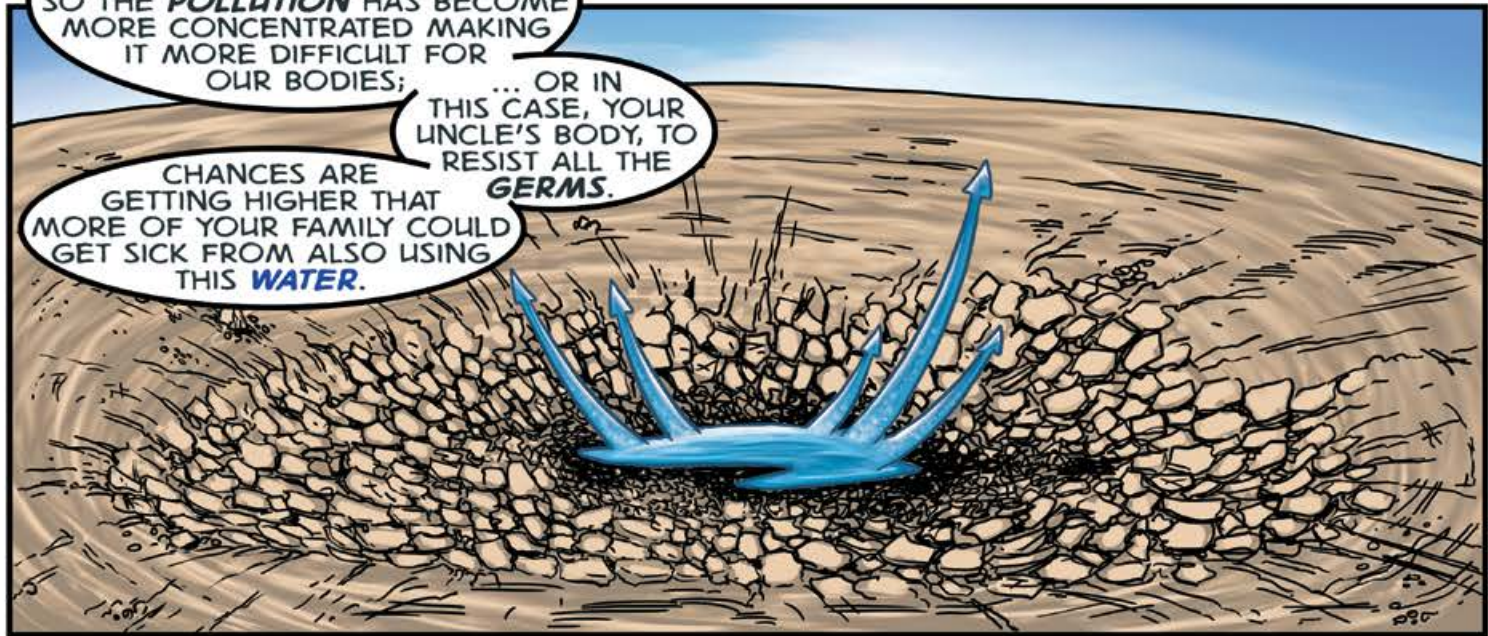
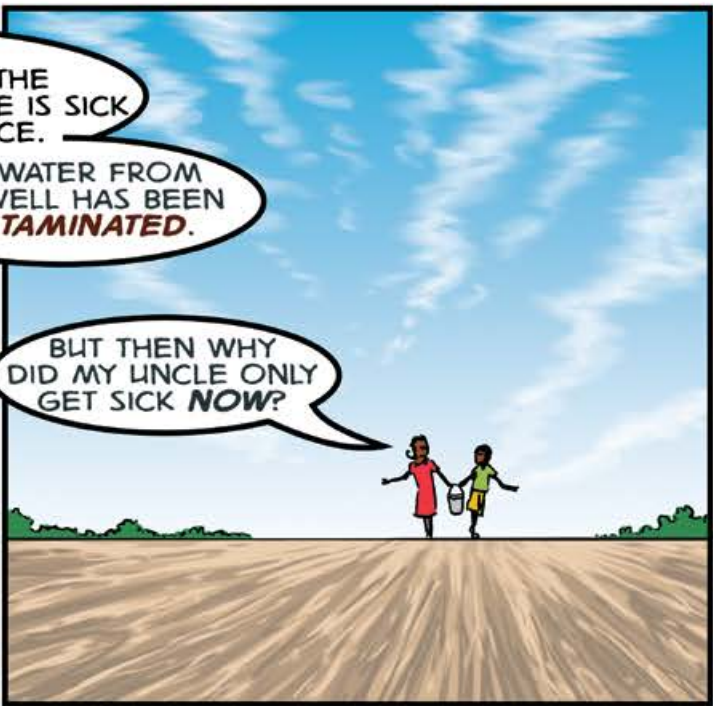
WHY NOT,
WE ALWAYS USE
THIS **WATER**?



WELL SAM THAT MIGHT BE THE **REASON** TULI'S UNCLE IS SICK IN THE FIRST PLACE.

THE WATER FROM THIS WELL HAS BEEN **CONTAMINATED**.

BUT THEN WHY DID MY UNCLE ONLY GET SICK **NOW**?



AS THE **WATER** HAS BEEN DRYING IT ALSO BECAME **STAGNANT**, SO THE **POLLUTION** HAS BECOME MORE CONCENTRATED MAKING IT MORE DIFFICULT FOR OUR BODIES;

... OR IN THIS CASE, YOUR UNCLE'S BODY, TO RESIST ALL THE **GERMS**.

CHANCES ARE GETTING HIGHER THAT MORE OF YOUR FAMILY COULD GET SICK FROM ALSO USING THIS **WATER**.



BUT TULI'S MOM SAID IT WAS A BUG THAT MADE UNCLE HAFENI **ILL**.

SHE IS RIGHT, BUT IT WAS NOT A BUG LIKE AN INSECT SAM, BUT RATHER A MICROSCOPIC **ORGANISM** CALLED A GERM THAT CAUSED UNCLE HAFENI TO GET SICK!



THIS IS **TERRIBLE!** IF WE CANNOT GIVE HIM THIS WATER THEN WHAT COULD WE DO?



THE BEST WOULD BE TO USE WATER FROM AN AVAILABLE BOREHOLE,



BUT FOR NOW BOILING THE WATER FOR A FEW MINUTES WILL ALREADY MAKE A BIG DIFFERENCE, AS THE HEAT WILL DESTROY MOST OF THE GERMS.



CLINICS ALSO SUPPLY THIS AREA WITH WATER PURIFYING TABLETS TO KILL EVEN MORE GERMS AND REMOVE HARMFUL CHEMICALS.

HEY! I REMEMBER MY DAD BROUGHT SOME TABLETS HE SAID WAS FOR CLEANING THE WATER, BUT WE DIDN'T USE IT BECAUSE WE THOUGHT IT WASN'T NECESSARY...



WELL TULI, I ADVISE THAT YOU USE IT FOR NOW TO HELP MAKE YOUR UNCLE BETTER.

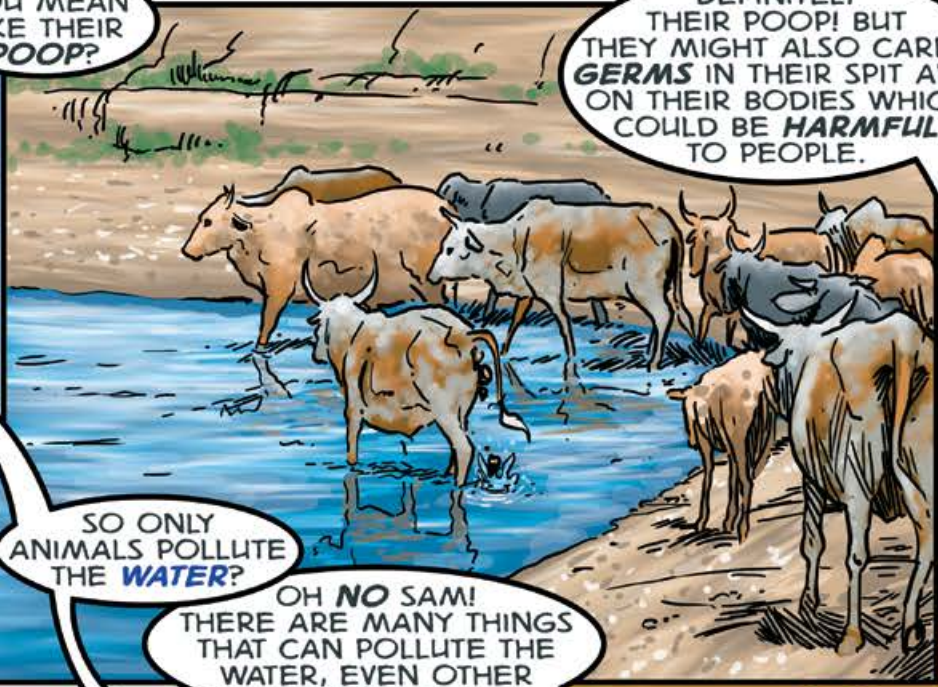
EVEN IF THE TABLETS ARE FINISHED YOU SHOULD ALWAYS BOIL THE WATER FROM THE HAND DUG WELL FIRST BEFORE GIVING IT TO HUMANS.

LOOK AT ALL THE ANIMALS HERE; THEY ARE A MAJOR REASON FOR THE CONTAMINATION.





YOU MEAN LIKE THEIR POOP?



DEFINITELY THEIR POOP! BUT THEY MIGHT ALSO CARRY **GERMS** IN THEIR SPIT AND ON THEIR BODIES WHICH COULD BE **HARMFUL** TO PEOPLE.

SO ONLY ANIMALS POLLUTE THE **WATER**?

OH **NO** SAM! THERE ARE MANY THINGS THAT CAN POLLUTE THE WATER, EVEN OTHER **PEOPLE**.

PEOPLE? PEOPLE CARRY MANY GERMS SAM, WHICH IS ALSO WHY WE SHOULD REGULARLY **WASH HANDS** AND **KEEP CLEAN**.



MR SMART ALSO SAID THAT. EVERY DAY AT SCHOOL WE HAVE TO **WASH OUR HANDS** BEFORE WE EAT, AND AFTER WE HAVE USED THE TOILET

AND HE IS RIGHT. KEEPING YOURSELF AND THE THINGS YOU USE **CLEAN**, ESPECIALLY FOR **EATING AND DRINKING**, IS VERY IMPORTANT TO **STAYING HEALTHY**.



HEY, WHAT ABOUT THAT BOREHOLE ON THE WAY TO SCHOOL?



I THINK TULI'S UNCLE REALLY NEEDS THIS WATER SAM,
WHY DON'T YOU TWO GO **BOIL** THIS WATER AND TREAT IT WITH A **TABLET** AND TOMORROW WE CAN FIND OUT IF THERE ARE ANY BOREHOLES IN THE AREA YOU MAY USE.

THE NEXT DAY ...

I WISH WE COULD GET IN THERE TO SEE IF THERE IS WATER IN THAT TAP...

GOOD MORNING KIDS, IS YOUR UNCLE BETTER TULI?

YES, MUCH BETTER! HE EVEN SAID THE WATER **TASTED** REALLY NICE FOR A CHANGE!

THAT IS GOOD NEWS, SO WHAT ARE YOU LOOKING AT HERE?



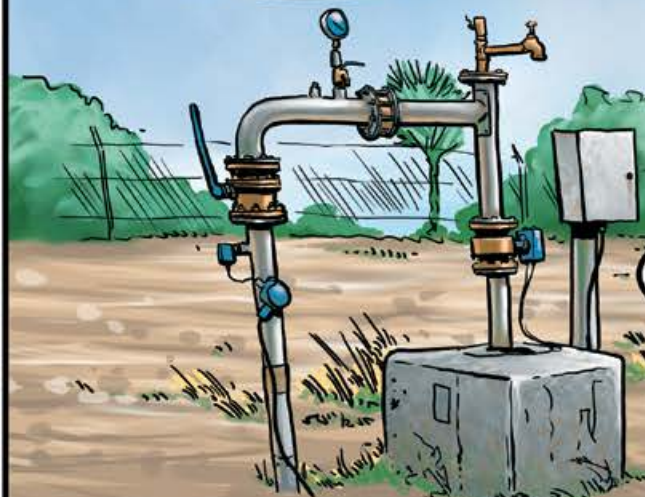
WELL THIS IS THE **BOREHOLE** I ASKED YOU ABOUT LAST NIGHT.

SOME TIME AGO WE SAW A DRILLING COMPANY DRILLING A HOLE HERE, BUT NOW THE GATE IS LOCKED AND IT SEEMS THAT THE BOREHOLE HAS BEEN CLOSED UP.

WE WANTED TO SEE IF WE COULD GET **WATER** FROM HERE IN THE FUTURE AS IT'S QUITE CLOSE TO HOME.

THEY DIDN'T **CLOSE UP** THE BOREHOLE; THE BOREHOLE IS NOW PUMPING WATER ELSEWHERE, THE PIPES YOU SEE SHOW THAT THIS IS A **PRODUCTION** BOREHOLE.

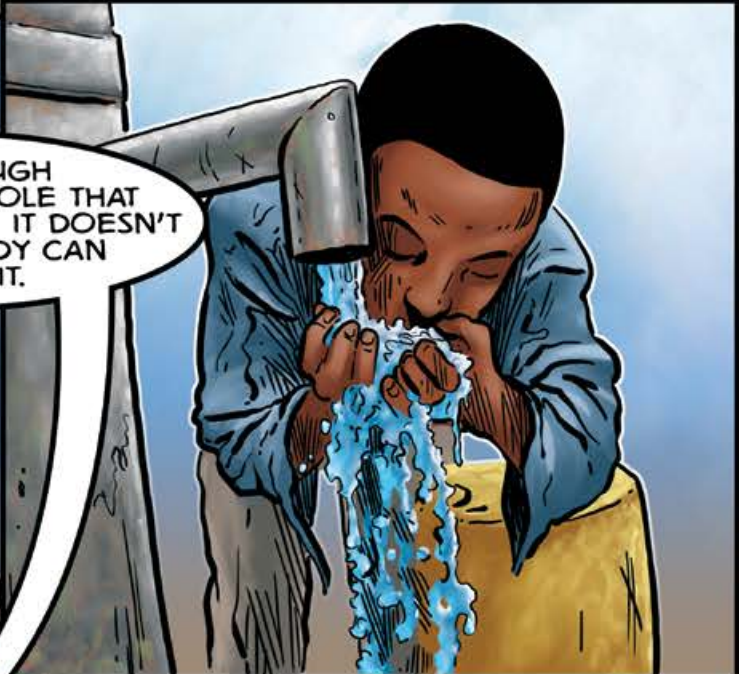
SOMETIMES THEY ONLY PUT ON A WELL TOP UNTIL THEY CAN MAKE SURE WHETHER THE **WATER** IS SUITABLE FOR HUMAN CONSUMPTION.



BUT I THOUGHT YOU SAID WE CAN USE **WATER** FROM A BOREHOLE.

NOT ALWAYS SAM.

EVEN THOUGH THIS IS A BOREHOLE THAT IS PUMPING WATER, IT DOESN'T MEAN ANYBODY CAN JUST USE IT.



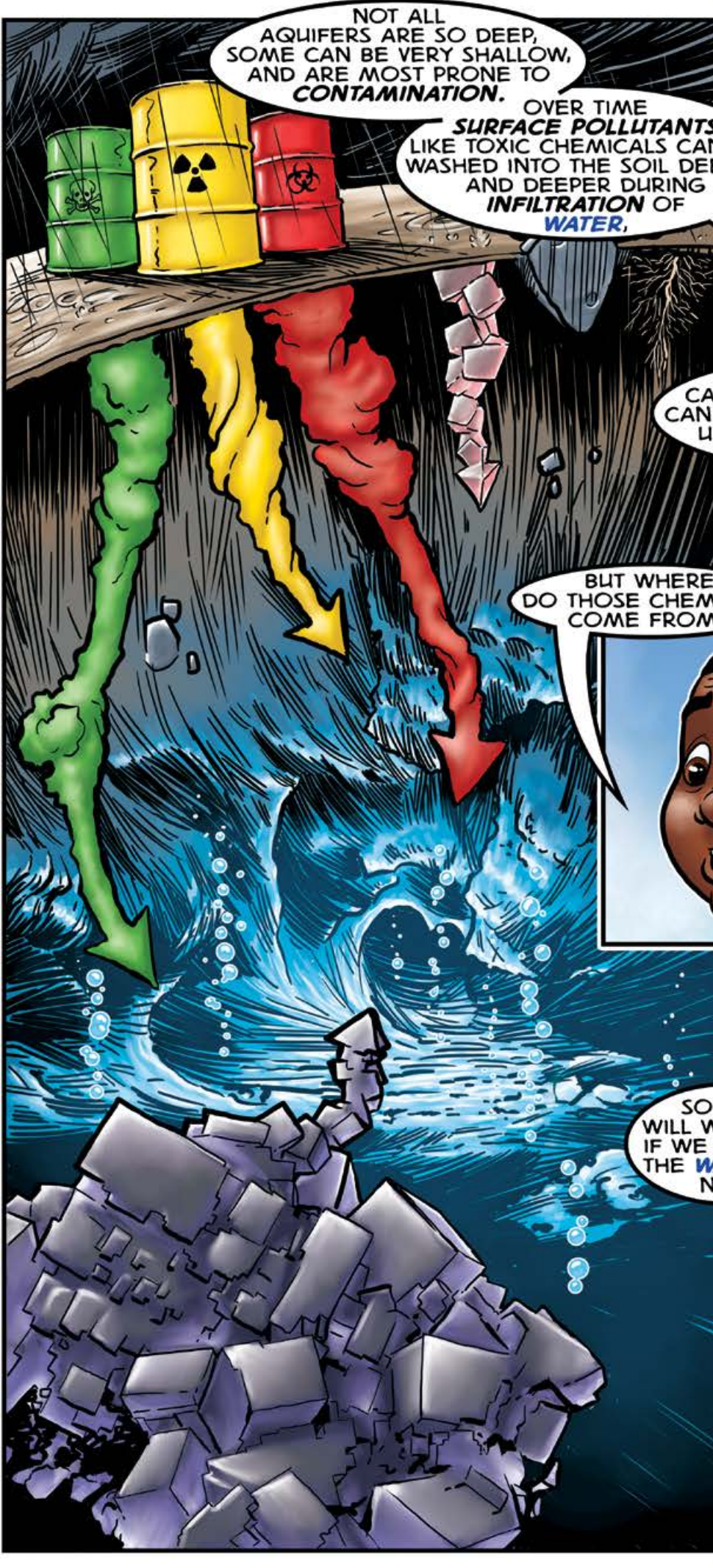
CONTROLLING USAGE IS VERY IMPORTANT TO THE **HEALTH** OF AN AQUIFER.

MAYBE THIS AQUIFER DOES NOT CONTAIN ENOUGH **WATER**, ...

... OR IT MIGHT SIMPLY BE THAT IT **TESTED NOT SAFE** FOR PEOPLE TO USE AND THE **WATER** IS USED FOR ANOTHER PURPOSE LIKE IRRIGATION.



BUT MR SMART SHOWED US THAT THE WATER LIES VERY DEEP IN THE EARTH, WHY WOULD IT **NOT** BE **SAFE**?



NOT ALL
AQUIFERS ARE SO DEEP,
SOME CAN BE VERY SHALLOW,
AND ARE MOST PRONE TO
CONTAMINATION.

OVER TIME
SURFACE POLLUTANTS
LIKE TOXIC CHEMICALS CAN BE
WASHED INTO THE SOIL DEEPER
AND DEEPER DURING
INFILTRATION OF
WATER.



BUT IN OTHER
CASES NATURAL ELEMENTS
CAN CAUSE THE **WATER** TO BE
UNSUITABLE FOR HUMAN
CONSUMPTION,

LIKE **SALTS,**
FLUORIDE OR EVEN
SULPHUR.

BUT WHERE
DO THOSE CHEMICALS
COME FROM?



YOU KNOW
THAT ALL STONES,
SAND AND ROCKS ARE
COMPOSED OF MINERALS
RIGHT? WELL, OVER LONG
PERIODS OF TIME THESE
NATURAL CHEMICALS
DISSOLVE INTO
THE **WATER.**

SO HOW
WILL WE KNOW
IF WE CAN USE
THE **WATER** OR
NOT?

THAT IS
WHAT THE
MONITORING IS
FOR TULI.



AAAH MAN, THAT SUCKS! IF IT'S NOT POOP IT'S THE STONES AROUND US. **WHAT ELSE CAN MAKE THE WATER BAD?**



WATER IS VERY VULNERABLE SAM. SOME INDUSTRIES LIKE MINING AND AGRICULTURE HAVE TO BE VERY CAREFUL NOT TO POLLUTE THE WATER TABLE AS THEY USE AND PRODUCE MANY CHEMICALS LIKE FERTILIZERS, PESTICIDES, ACIDS AND OTHER INDUSTRIAL WASTAGE THAT COULD HARM PEOPLE.



HEY WAIT A MINUTE, DR ROCK IS A **HYDROGEOLOGIST**. I BET SHE KNOWS WHERE WE COULD FIND A USABLE BOREHOLE.



THAT'S A GREAT IDEA TULLI, ...



HOLD ON!!!



CLOSE BY...



KNOCK KNOCK ...



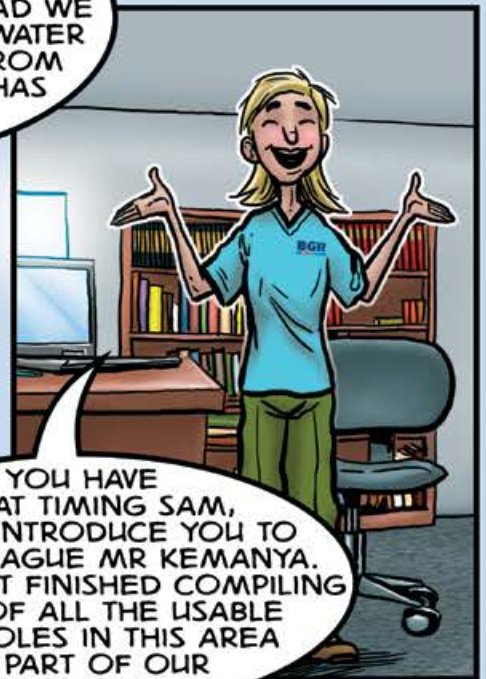
Hi...



HEY KIDS!
GOODNESS WHAT
A SURPRISE! WHAT
CAN I DO FOR
YOU?



UUH...
HI DR ROCK!
WE CAME TO ASK YOU IF
YOU KNOW OF ANY BOREHOLES
CLOSE TO OUR HOMESTEAD WE
CAN USE TO GET CLEAN WATER
FROM, AS THE WATER FROM
OUR HAND DUG WELL HAS
BECOME VERY
DIRTY.



YOU HAVE
GREAT TIMING SAM,
LET ME INTRODUCE YOU TO
MY COLLEAGUE MR KEMANYA.
HE HAS JUST FINISHED COMPILING
A LIST OF ALL THE USABLE
BOREHOLES IN THIS AREA
AS PART OF OUR
RESEARCH.

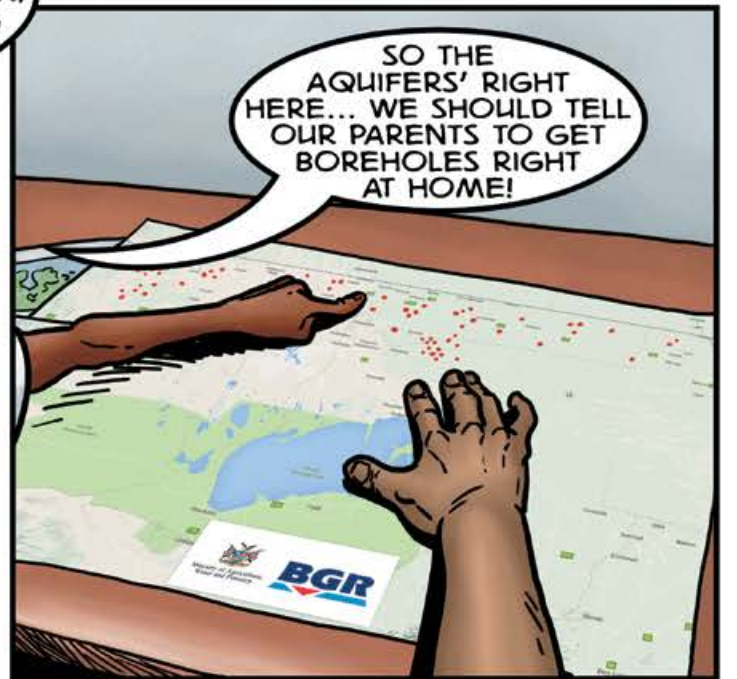


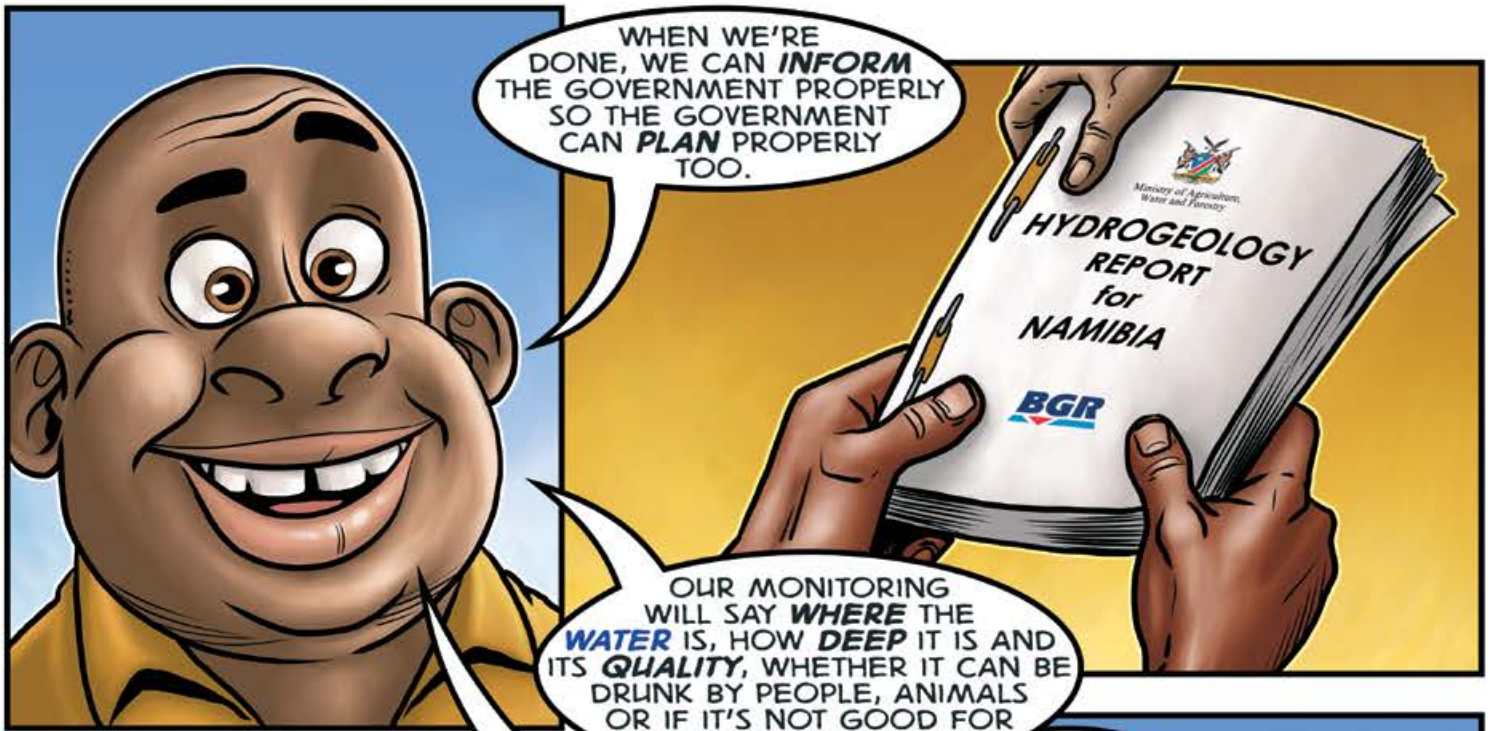
HI GUYS,
COME LOOK AT
THIS MAP I HAVE
CREATED.

THIS IS THE
CLOSEST BIG TOWN
FROM HERE, SO THIS
SHOULD BE WHERE
YOUR VILLAGE IS.

OVER HERE
AND HERE ARE BOREHOLES
THAT ARE CURRENTLY OPEN FOR
PEOPLE TO USE AND QUITE CLOSE
TO YOUR HOMESTEAD, RIGHT ON
TOP OF THE OHANGWENA
II AQUIFER.

OHANGWENA II
AQUIFER?





WHEN WE'RE DONE, WE CAN **INFORM** THE GOVERNMENT PROPERLY SO THE GOVERNMENT CAN **PLAN** PROPERLY TOO.

OUR MONITORING WILL SAY **WHERE** THE **WATER** IS, HOW **DEEP** IT IS AND ITS **QUALITY**, WHETHER IT CAN BE DRUNK BY PEOPLE, ANIMALS OR IF IT'S NOT GOOD FOR DRINKING AT ALL.



IT IS **SAM**; **WATER** IS FOR **EVERYONE** SO THE GOVERNMENT HAS TO HELP US TO LOOK AFTER IT!



WOW! THAT SEEMS LIKE A LOT OF WORK!



YOUR PARENTS WILL HAVE TO GET **PERMISSION** TO DRILL AND THEN GOVERNMENT WILL TELL THEM WHAT THE **WATER** QUALITY IS AND FOR WHAT IT CAN BE USED.

WE BETTER GET HOME, **THANKS** MR KEMANYA.

YES THANKS AND GOOD LUCK WITH YOUR PROJECT.

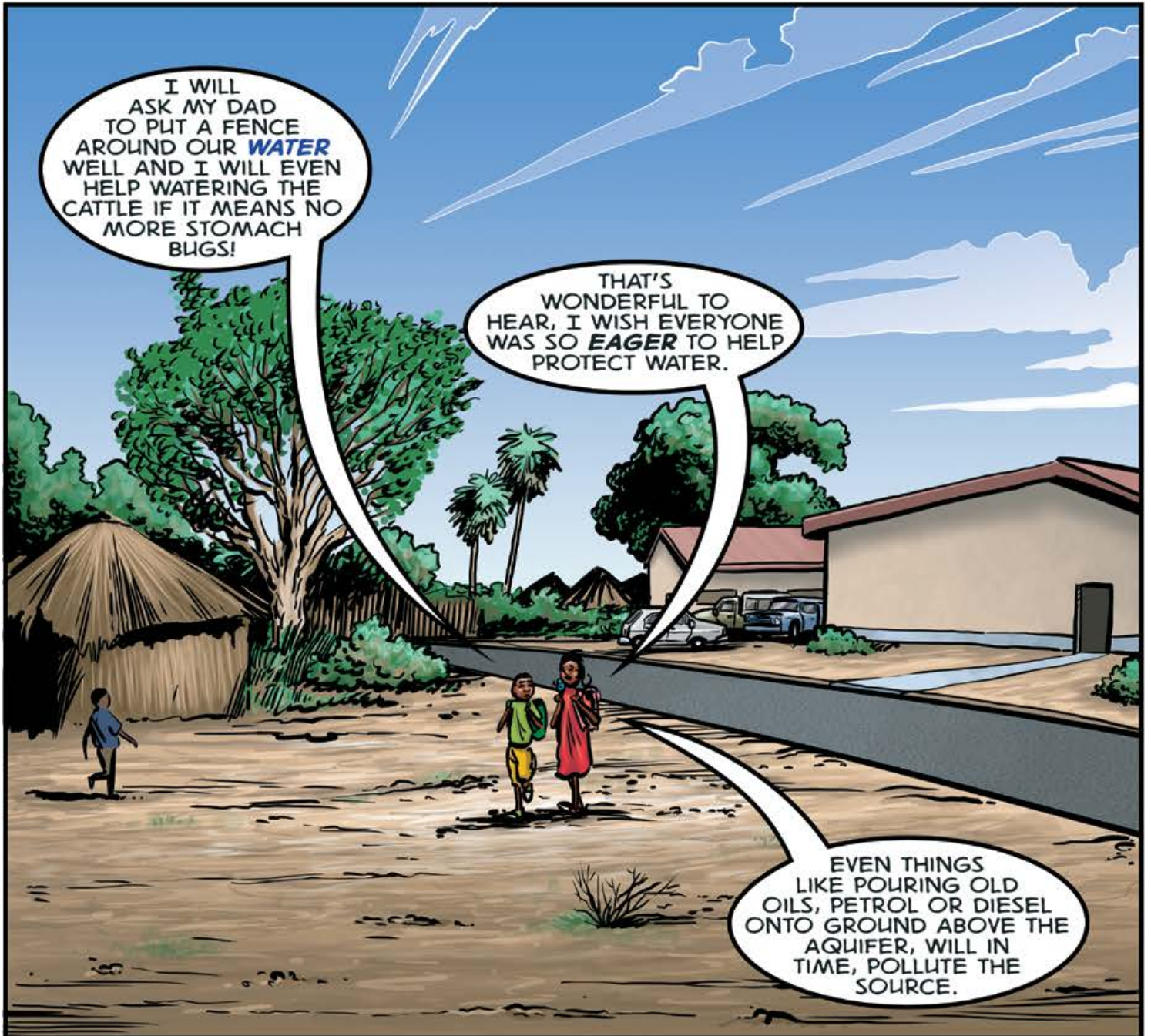


I BET OURS WILL BE THE BEST QUALITY WATER!

YEAH! AND WE WOULDN'T HAVE TO RELY ON THE **RAINS**...WE COULD EVEN **WATER** OUR MAHANGO!



MAYBE! BUT THE HYDROGEOLOGISTS WILL STILL HAVE TO **MONITOR** THE WHOLE AQUIFER, TO MAKE SURE THAT IT STAYS CLEAN AND IS NOT **OVER USED** OR **POLLUTED**.



I WILL ASK MY DAD TO PUT A FENCE AROUND OUR **WATER** WELL AND I WILL EVEN HELP WATERING THE CATTLE IF IT MEANS NO MORE STOMACH BUGS!

THAT'S WONDERFUL TO HEAR, I WISH EVERYONE WAS SO **EAGER** TO HELP PROTECT WATER.

EVEN THINGS LIKE POURING OLD OILS, PETROL OR DIESEL ONTO GROUND ABOVE THE AQUIFER, WILL IN TIME, POLLUTE THE SOURCE.



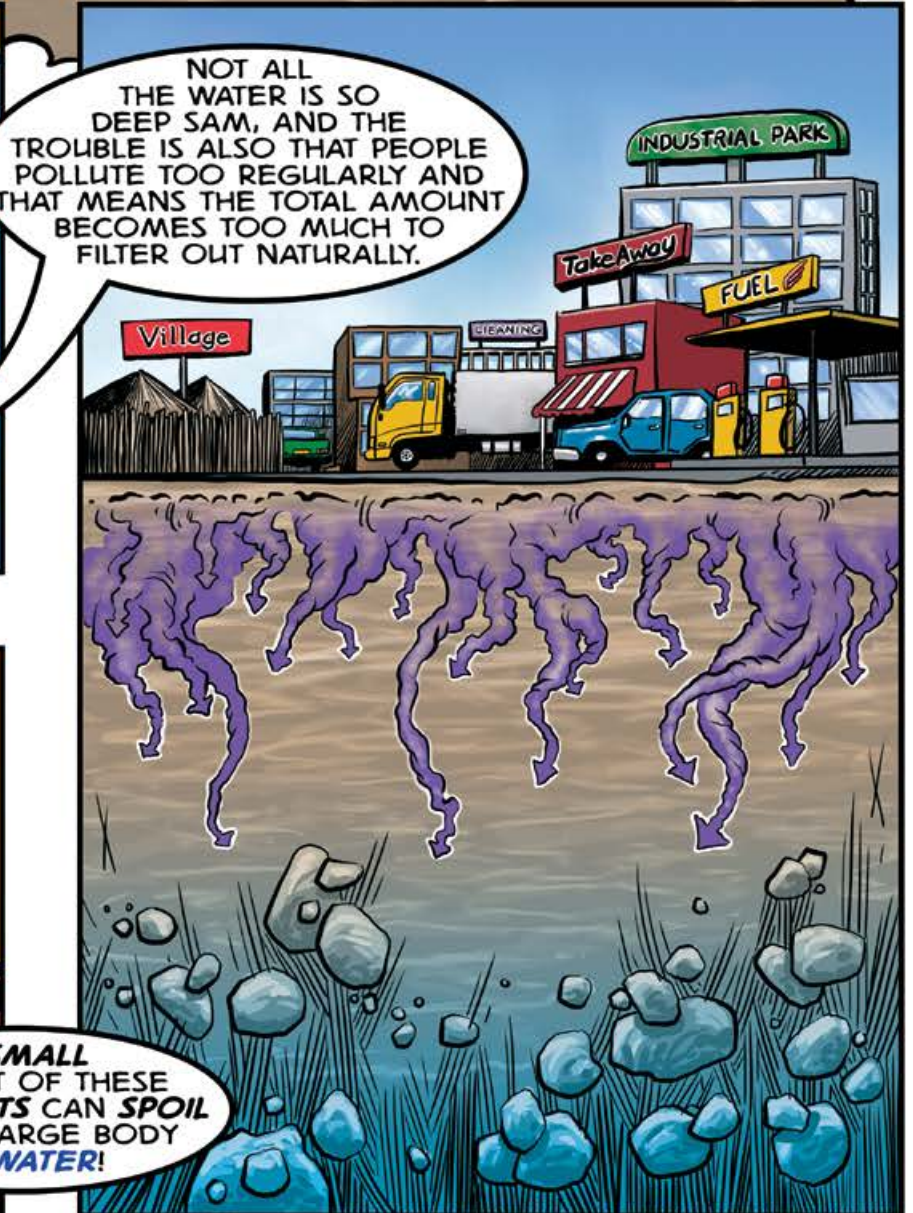
DON'T WORRY H_2O ... IT'S NOT MUCH WHEN YOU CHANGE THE OIL; I'VE SEEN MY UNCLE DO IT.



NO IT'S NOT... BUT... THERE ARE A LOT OF PEOPLE DOING IT! PUT ALL THEIR LITTLE AMOUNTS OF OIL TOGETHER AND IT SOON BECOMES A LOT!



BUT MR KEMANYA SAID THE WATER IS SO DEEP. DOESN'T THE SAND FILTER IT OUT?



NOT ALL THE WATER IS SO DEEP SAM, AND THE TROUBLE IS ALSO THAT PEOPLE POLLUTE TOO REGULARLY AND THAT MEANS THE TOTAL AMOUNT BECOMES TOO MUCH TO FILTER OUT NATURALLY.



A SMALL AMOUNT OF THESE POLLUTANTS CAN SPOIL A VERY LARGE BODY OF WATER!

SOME MONTHS LATER DURING **HARVEST TIME**



HEY TULI,
I WENT TO YOUR
HOUSE AND YOUR MOM
SAID YOU ARE HERE,
SHE ASKED ME TO
BRING YOU SOME
COOLDRINK.

PHEW,
THANKS SAM,
I'M REALLY
THIRSTY!

AAH,
THAT'S NICE. I'M
REALLY GLAD MY PARENTS
HAVE SORTED OUT OUR **WATER**
SITUATION SO THAT IT IS
ALWAYS NICE AND
CLEAN.

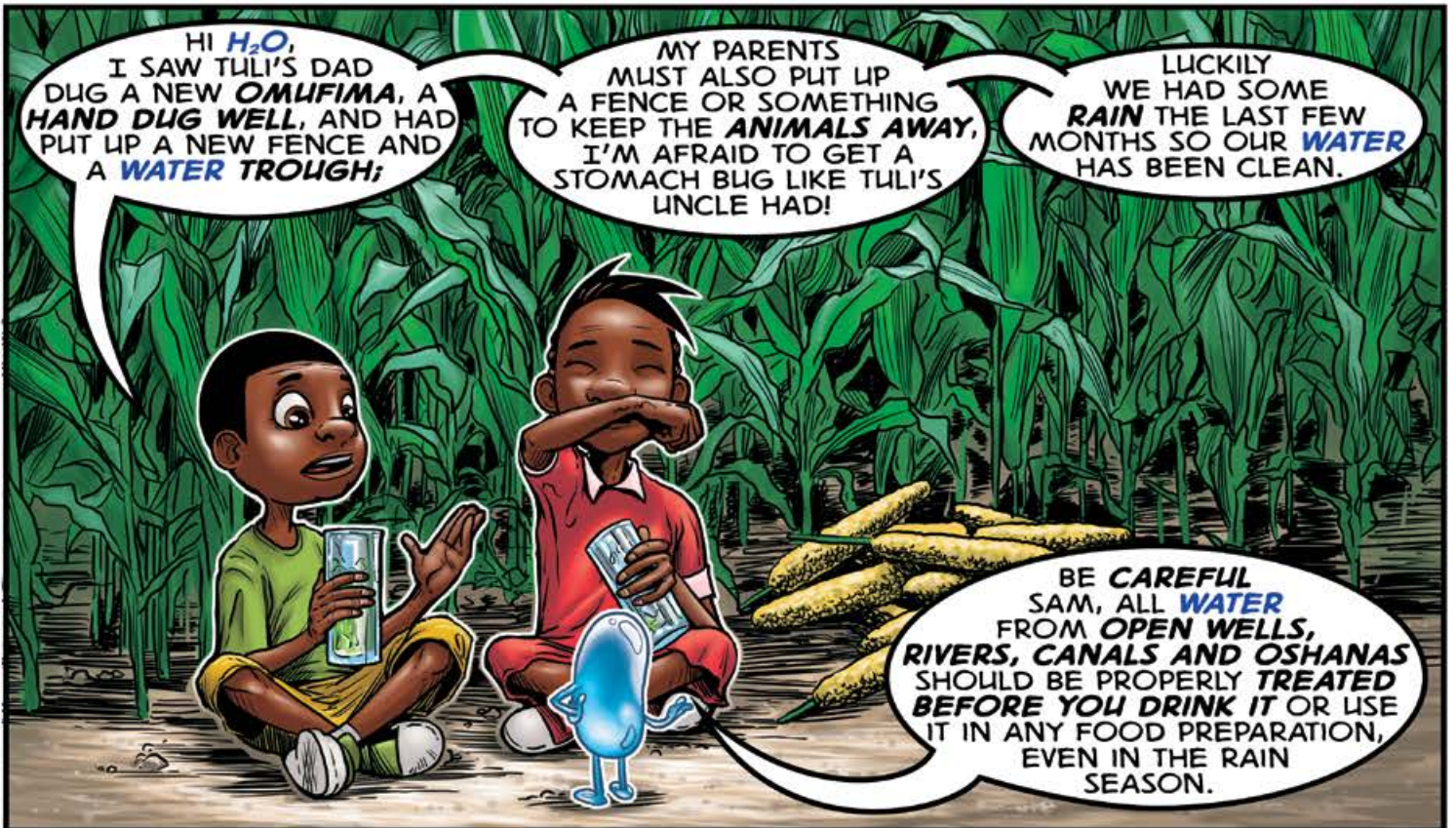
HEY KIDS!
WHAT'S NEWS?



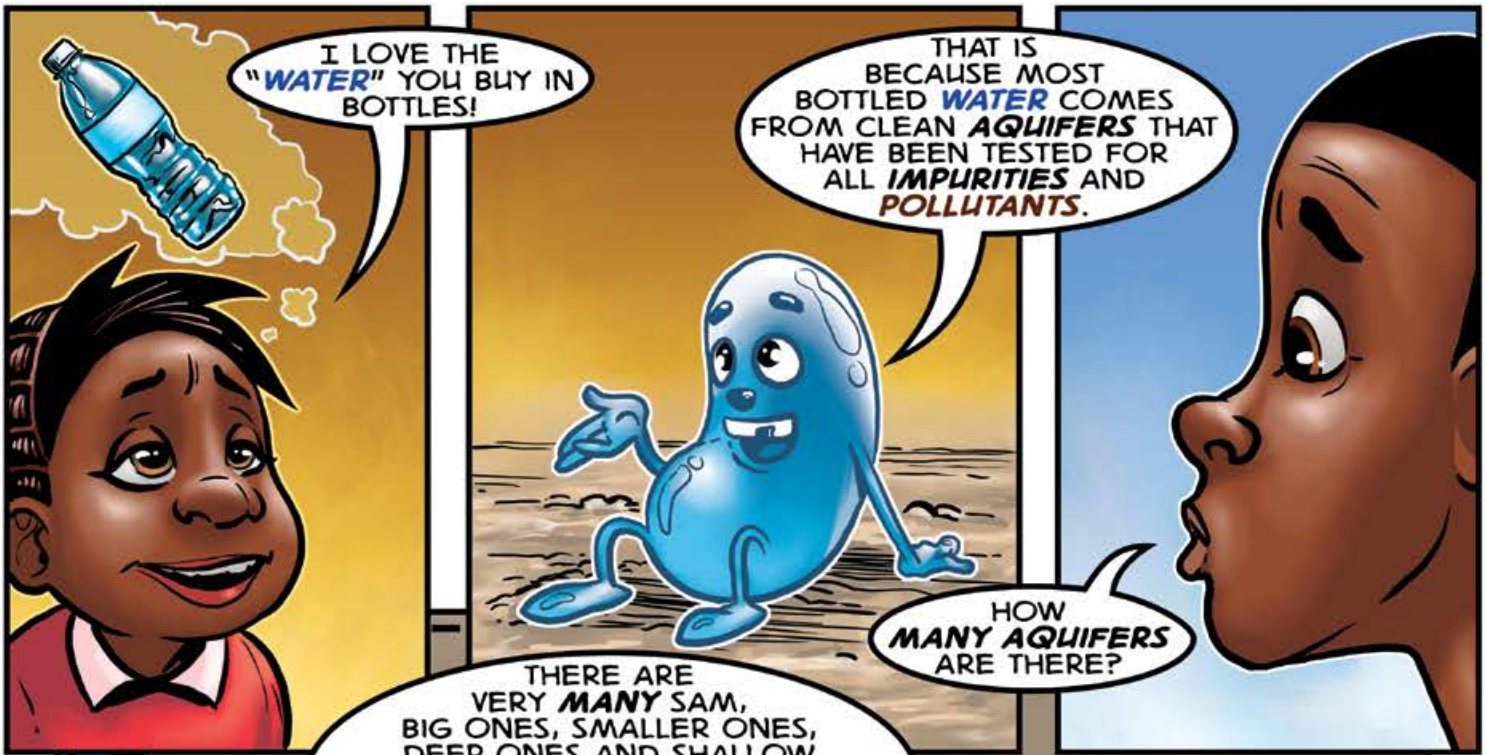
HI **H₂O**,
I SAW TULI'S DAD
DUG A NEW **OMUFIMA**, A
HAND DUG WELL, AND HAD
PUT UP A NEW FENCE AND
A **WATER TROUGH**;

MY PARENTS
MUST ALSO PUT UP
A FENCE OR SOMETHING
TO KEEP THE **ANIMALS AWAY**,
I'M AFRAID TO GET A
STOMACH BUG LIKE TULI'S
UNCLE HAD!

LUCKILY
WE HAD SOME
RAIN THE LAST FEW
MONTHS SO OUR **WATER**
HAS BEEN CLEAN.

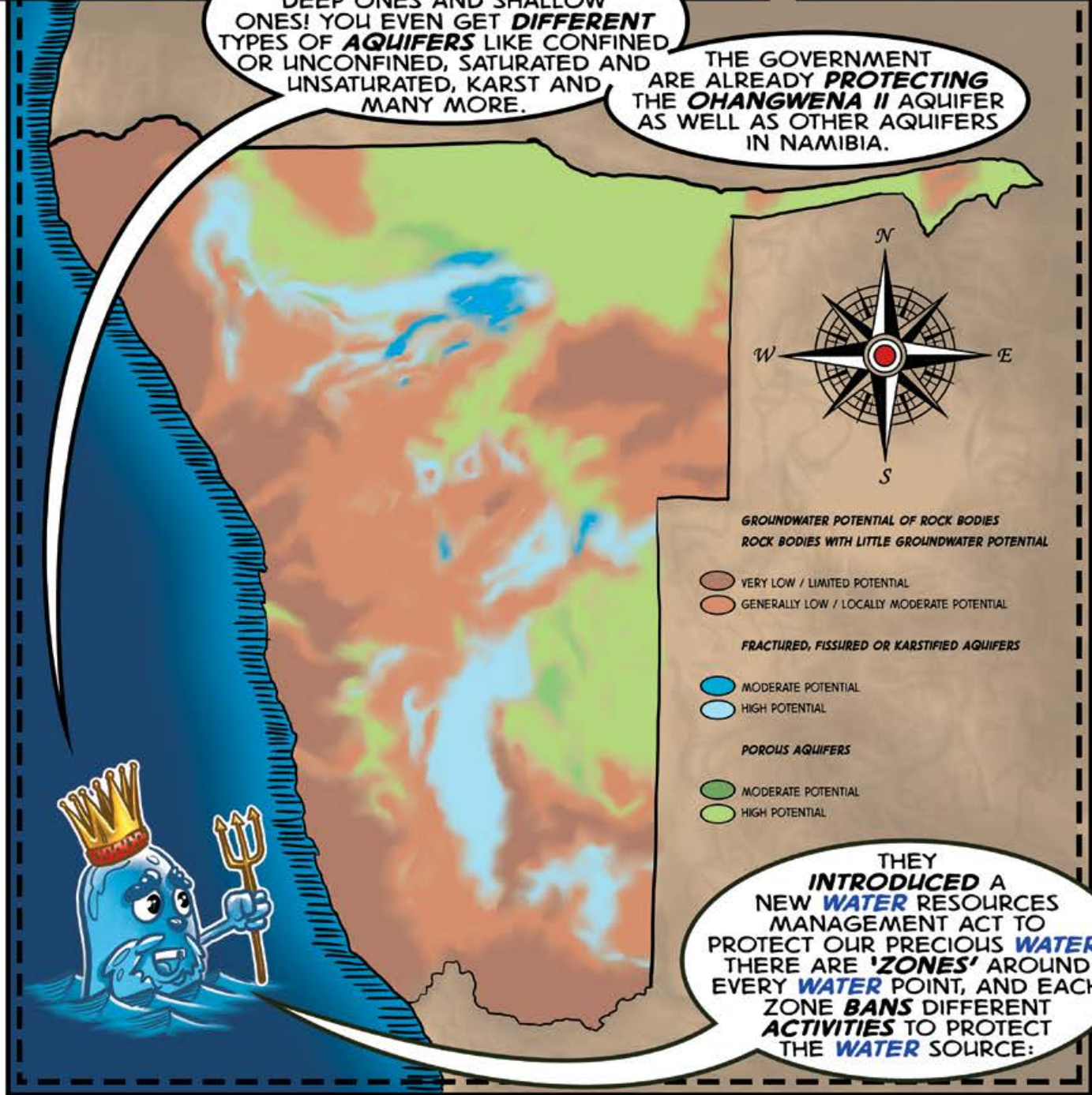


BE **CAREFUL**
SAM, ALL **WATER**
FROM **OPEN WELLS**,
RIVERS, CANALS AND OSHANAS
SHOULD BE PROPERLY **TREATED**
BEFORE YOU DRINK IT OR USE
IT IN ANY FOOD PREPARATION,
EVEN IN THE **RAIN**
SEASON.



THERE ARE VERY **MANY** SAM, BIG ONES, SMALLER ONES, DEEP ONES AND SHALLOW ONES! YOU EVEN GET **DIFFERENT** TYPES OF **AQUIFERS** LIKE CONFINED OR UNCONFINED, SATURATED AND UNSATURATED, KARST AND MANY MORE.

THE GOVERNMENT ARE ALREADY **PROTECTING** THE **OHANGWENA II** AQUIFER AS WELL AS OTHER AQUIFERS IN NAMIBIA.



THEY **INTRODUCED** A NEW **WATER** RESOURCES MANAGEMENT ACT TO PROTECT OUR PRECIOUS **WATER**. THERE ARE '**ZONES**' AROUND EVERY **WATER** POINT, AND EACH ZONE **BANS** DIFFERENT **ACTIVITIES** TO PROTECT THE **WATER** SOURCE:



THE **ZONE** DIRECTLY AROUND THE BOREHOLE MUST BE FENCED AND IS A 'NO GO!' AREA. **NO ANIMALS, NO DUMPING AND NO BUILDING!**

THE NEXT DESIGNATED **ZONE** SHOULD NOT HAVE **BIG BUILDINGS** OR MAJOR **CONSTRUCTION, GRAZING** OF ANIMALS, AND **PESTICIDES** AND **FERTILISERS** SHOULD BE AVOIDED.

NO HEAVY INDUSTRY OR **FUEL STATIONS** SHOULD BE ALLOWED IN THE FINAL **ZONE**, AND BEYOND THAT EVERYTHING CAN CARRY ON NORMALLY.

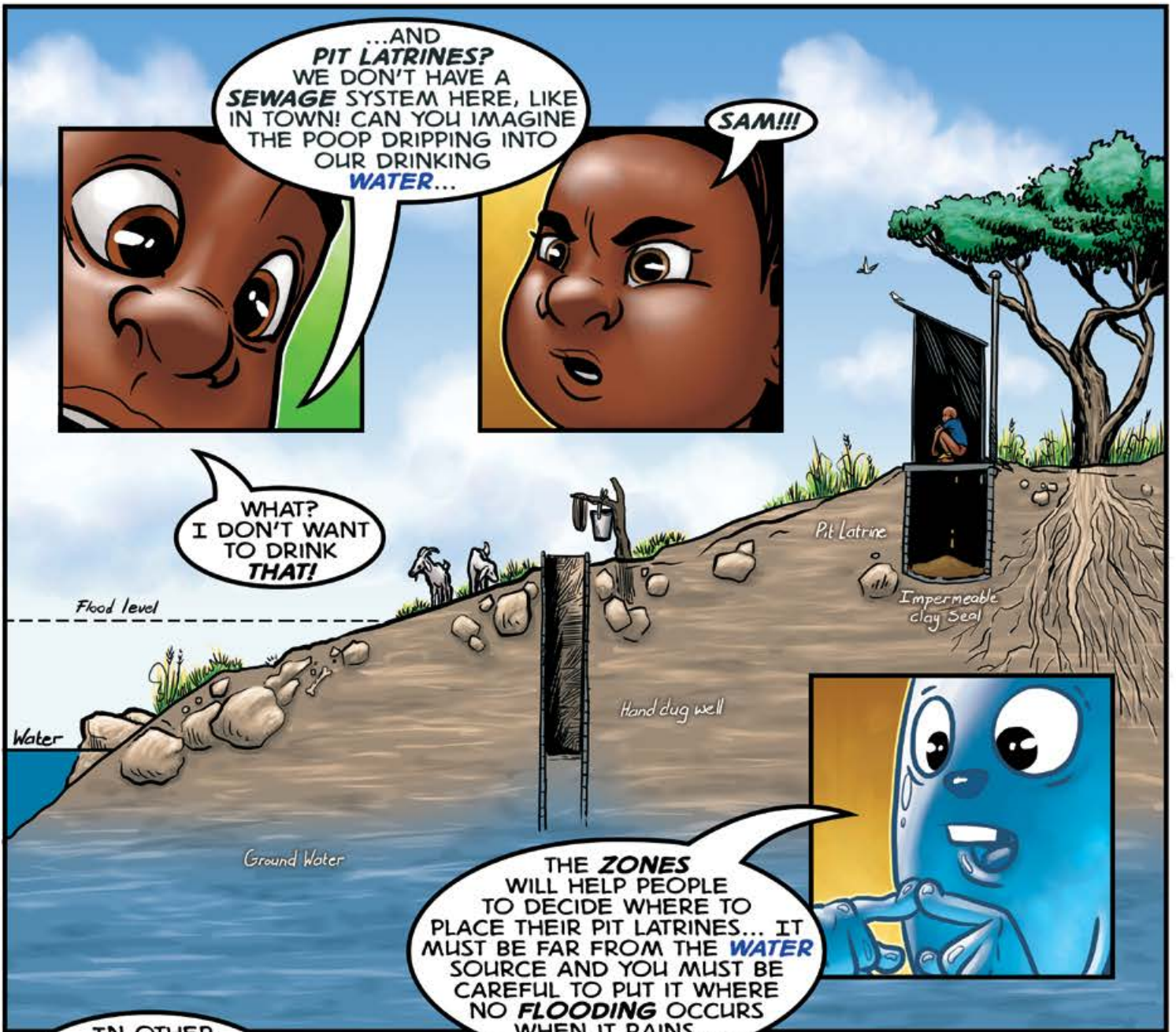


HOW BIG ARE THESE ZONES?



EACH WELL OR BOREHOLE WILL BE DIFFERENT, DEPENDING ON THE **DEPTH** OF THE AQUIFER AND ITS **WATER QUALITY**.





...AND **PIT LATRINES?** WE DON'T HAVE A **SEWAGE** SYSTEM HERE, LIKE IN TOWN! CAN YOU IMAGINE THE POOP DRIPPING INTO OUR DRINKING **WATER...**

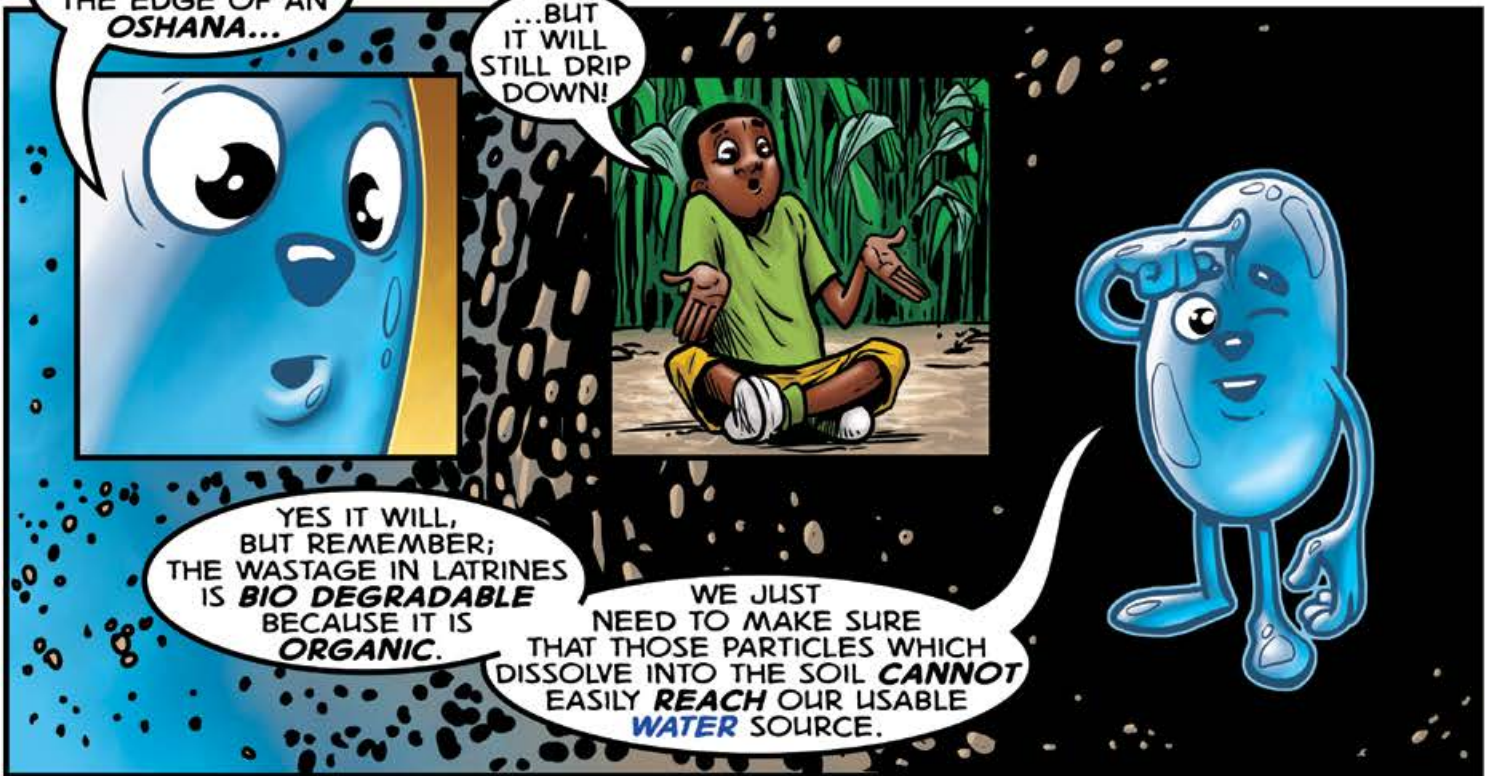
SAM!!!

WHAT? I DON'T WANT TO DRINK **THAT!**

THE **ZONES** WILL HELP PEOPLE TO DECIDE WHERE TO PLACE THEIR PIT LATRINES... IT MUST BE FAR FROM THE **WATER** SOURCE AND YOU MUST BE CAREFUL TO PUT IT WHERE NO **FLOODING** OCCURS WHEN IT RAINS...


IN OTHER WORDS, **NOT** ON THE EDGE OF AN **OSHANA...**

...BUT IT WILL STILL DRIP DOWN!



YES IT WILL, BUT REMEMBER; THE WASTAGE IN LATRINES IS **BIO DEGRADABLE** BECAUSE IT IS **ORGANIC.**

WE JUST NEED TO MAKE SURE THAT THOSE PARTICLES WHICH DISSOLVE INTO THE SOIL **CANNOT** EASILY **REACH** OUR USABLE **WATER** SOURCE.



I'M GOING TO TRY REALLY HARD TO GET OTHERS TO UNDERSTAND WHAT'S GOING ON UNDER OUR FEET HERE.

WE HAVE TO DO SOMETHING TULI... WE ALL NEED CLEAN 'WATER'...

NOW THAT YOU **UNDERSTAND** MORE ABOUT ME, YOU WILL CHANGE THINGS FOR THE BETTER TO **PROTECT** ME AND KEEP ME HEALTHY.

TULI, SAM!
COME IN BEFORE YOU GET COLD FROM THE **RAIN!**

LOOKS LIKE GRANDMA IS RIGHT.





SOMETIMES IT'S CLEAR TO KNOW HOW MUCH WATER THERE WILL BE BECAUSE OF THE RAIN WE CAN SEE,



HOWEVER; HYDROGEOLOGISTS HAVE FOUND LOTS OF WATER UNDERGROUND TO SUPPLY PEOPLE WITH.



NOW THEY ARE TEACHING US THERE ARE NEW AND MORE ACCURATE WAYS OF KNOWING THE WATER SITUATION AT ANY PLACE AND TIME.

BUT! ... EVERY PERSON MUST HELP WHERE THEY CAN, TO **IMPROVE** WHAT YOU ALREADY HAVE AND NOT BEHAVE IN A WAY THAT WILL SPOIL WHAT YOU COULD HAVE IN THE FUTURE! ... PLEASE EVERYONE,



BE WATER WISE!!!

Groundwater Management in the North of Namibia presents:

**The incredible adventures of
H₂O
& his friends**



**Federal Institute for Geosciences and Natural Resources (BGR)
(Bundesanstalt für Geowissenschaften und Rohstoffe, BGR)**

BGR is the geoscientific competence centre and the geological survey of the Federal Republic of Germany. The main topics it deals with are energy resources, mineral resources, groundwater, soil, and the use of the underground for storage and economic purposes. Its responsibilities include carrying out research and consultation to help maintain and improve living conditions by ensuring the responsible use of geological potential. BGR exercises its responsibilities in compliance with the needs of politics, industry and society as a whole.

Sustainable groundwater management as the fundamental basis of life for future generations

Water is essential for the life of humans, animals and plants. Drinking water in many countries is largely supplied from groundwater – more than 70 per cent in the case of Germany for instance. In the arid zones around the world, groundwater is often the only reliable water resource available to people. The importance of groundwater will increase considerably against the background of the rising global population and climate change. Approximately 800 million people around the world have no access to clean drinking water. BGR, as an official implementation organisation of German development co-operation, therefore assists its partner countries in the sustainable use and protection of groundwater resources.

Groundwater Management in the Cuvelai-Etосha Basin, Namibia

Access to safe freshwater is the main limiting factor for the economic and social development of Namibia. Surface water is restricted to four perennial rivers at the Northern and Southern borders. As in most arid countries groundwater plays a vital role for the supply of wide areas in Namibia. As part of the technical co-operation between Namibia and Germany, the Government of the Federal Republic of Germany provided financial and technical support through the project “Groundwater Management in the North of Namibia” executed by the Ministry of Agriculture, Water and Forestry (MAWF) and the Federal Institute for Geosciences and Natural Resources (BGR). The goal of this project is to improve access to safe drinking water and to provide well founded information concerning the groundwater resources in the Cuvelai-Etосha Basin (CEB).



BE WATER WISE!



german
cooperation

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