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(54) Title: TREATMENT OF AQUEOUS SUSPENSIONS

(57) **Abrégé/Abstract:**

A process in which material comprising an aqueous liquid with dispersed particulate solids is transferred as a fluid to a deposition area, then allowed to stand and rigidify, and in which rigidification is improved whilst retaining the fluidity of the material during transfer, by combining with the material an effective rigidifying amount of aqueous solution of a water-soluble polymer. The process is particularly suitable for the treatment of the tailings underflow resulting oil sands processing operation and the co-disposal of fine and coarse tailings fractions. In addition, liquor released during the rigidification step is of high clarity.



Abstract

Treatment of Aqueous Suspensions

5 A process in which material comprising an aqueous liquid with dispersed
particulate solids is transferred as a fluid to a deposition area, then allowed
to stand and rigidify, and in which rigidification is improved whilst retaining
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coarse tailings fractions. In addition, liquor released during the rigidification
step is of high clarity.

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Treatment of Aqueous Suspensions

- 5 The present invention relates to the treatment of mineral material, especially waste mineral slurries. The invention is particularly suitable for the disposal of tailings and other waste material resulting from mineral or oil sands processing and beneficiation processes, including the co-disposal of coarse and fine solids, as a homogenous mixture.

10

Processes of treating mineral ores or oil sands in order to extract mineral values or in the case of oil sands to extract bitumen will normally result in waste material. Often the waste material consists of an aqueous slurry or sludge comprising particulate mineral material, for instance clay, shale, sand, 15 grit, oil sand tailings, metal oxides etc admixed with water.

In some cases the waste material such as mine tailings can be conveniently disposed of in an underground mine to form backfill. Generally backfill waste comprises a high proportion of coarse large sized particles together with 20 other smaller sized particles and is pumped into the mine as slurry where it is allowed to dewater leaving the sedimented solids in place. It is common practice to use flocculants to assist this process by flocculating the fine material to increase the rate of sedimentation. However, in this instance, the coarse material will normally sediment at a faster rate than the flocculated 25 fines, resulting in a heterogeneous deposit of coarse and fine solids.

For other applications it may not be possible to dispose of the waste in a mine. In these instances, it is common practice to dispose of this material by pumping the aqueous slurry to lagoons, heaps or stacks and allowing it to 30 dewater gradually through the actions of sedimentation, drainage and evaporation.

For example in oil sands processing, the ore is processed to recover the bitumen fraction, and the remainder, including both process material and the gangue, constitutes the tailings that are not valuable and are to be disposed of. In oil sands processing, the main process material is water, and the
5 gangue is mostly sand with some silt and clay. Physically, the tailings consist of a solid part (sand tailings) and a more or less fluid part (sludge). The most satisfactory place to dispose of these tailings is, of course, in the existing excavated hole in the ground. It turns out, however, that the sand tailings alone from the one cubic foot of ore occupy just about one cubic foot.
10 The amount of sludge is variable, depending on ore quality and process conditions, but average about 0.3 cubic feet. The tailings simply will not fit back into the hole in the ground.

There is a great deal of environmental pressure to minimise the allocation of
15 new land for disposal purposes and to more effectively use the existing waste areas. One method is to load multiple layers of waste onto an area to thus form higher stacks of waste. However, this presents a difficulty of ensuring that the waste material can only flow over the surface of previously rigidified waste within acceptable boundaries, is allowed to rigidify to form a
20 stack, and that the waste is sufficiently consolidated to support multiple layers of rigidified material, without the risk of collapse or slip. Thus the requirements for providing a waste material with the right sort of characteristics for stacking is altogether different from those required for other forms of disposal, such as back-filling within a relatively enclosed area.

25

In a typical mineral or oil sands processing operation, waste solids are separated from solids that contain mineral values in an aqueous process. The aqueous suspension of waste solids often contain clays and other minerals, and are usually referred to as tailings. These solids are often
30 concentrated by a flocculation process in a thickener to give a higher density underflow and to recover some of the process water. It is usual to pump the underflow to a surface holding area, often referred to as a tailings pit or dam. Once deposited at this surface holding area, water will continue to be

released from the aqueous suspension resulting in further concentration of the solids over a period of time. Once a sufficient volume of water has been collected this is usually pumped back to the mineral or oil sands processing plant.

5

The tailings dam is often of limited size in order to minimise the impact on the environment. In addition, providing larger dams can be expensive due to the high costs of earth moving and the building of containment walls. These dams tend to have a gently sloping bottom which allows any water released from the solids to collect in one area and which can then be pumped back to the plant. A problem that frequently occurs is when fine particles of solids are carried away with the run-off water, thus contaminating the water and having a detrimental impact on subsequent uses of the water.

15 In many mineral and oil sands processing operations, for instance a mineral sands beneficiation process, it is also common to produce a second waste stream comprising of mainly coarse (> 0.1 mm) mineral particles. It is particularly desirable to dispose of the coarse and fine waste particles as a homogeneous mixture as this improves both the mechanical properties of the dewatered solids, greatly reducing the time and the cost eventually
20 required to rehabilitate the land. However, this is not usually possible because even if the coarse waste material is thoroughly mixed into the aqueous suspension of fine waste material prior to deposition in the disposal area, the coarse material will settle much faster than the fine material
25 resulting in banding within the dewatered solids. Furthermore, when the quantity of coarse material to fine material is relatively high, the rapid sedimentation of the coarse material may produce excessive beach angles which promote the run off of aqueous waste containing high proportions of fine particles, further contaminating the recovered water. As a result, it is
30 often necessary to treat the coarse and fine waste streams separately, and recombine these materials by mechanically re-working, once the dewatering process is complete.

Attempts have been made to overcome all the above problems by treating the feed to the tailings dam using a coagulant or a flocculant to enhance the rate of sedimentation and/or improve the clarity of the released water.

However, this has been unsuccessful as these treatments have been applied
5 at conventional doses and this has brought about little or no benefit in either rate of compaction of the fine waste material or clarity of the recovered water.

It would therefore be desirable to provide treatment which provides more
10 rapid release of water from the suspension of solids. In addition it will be desirable to enable the concentrated solids to be held in a convenient manner that prevent both segregation of any coarse and fine fractions, and prevent contamination of the released water whilst at the same time minimise the impact on the environment.

15 In the process for recovery of heavy oil and bitumen from oil sand deposits, when using open cast mining, the oil or bitumen is extracted either by a hot-water process in which oil sands are mixed with 65 °C (150 °F) water and caustic or by a low-energy extraction process run at lower temperatures
20 without caustic. However, both processes generate large volumes of tailings which consist of the whole oil sand ore body plus net additions of process water less only the recovered bitumen product.

These oil sand tailings can be subdivided into three categories; viz.: (1)
25 screen oversize, (2) coarse or sand tailings (the fraction that settles rapidly), and (3) fine or tailings sludge (the fraction that settles slowly). Thus the oil sands tailing are made up of particles of different sizes.

Typically these oil sand tailings are piped to a tailings pond for disposal. The
30 coarse sands settle first with fine particles settling only very slowly. These fine particles form highly stable fines suspensions in water containing as much as about 30 percent by weight solids. Over time these fine particles

settle to form a substantially solid clay sediment thus filling the lagoon and requiring the creation of new lagoons.

5 It is well known to concentrate these oil sand tailings in a thickener to give a higher density underflow and to recover some of the process water as mentioned above.

For example, Xu.Y et al, *Mining Engineering*, November 2003, p.33-39 describes the addition of anionic flocculants to the oil sand tailings in the
10 thickener before disposal.

The underflow can be disposed of and/or subjected to further drying for subsequent disposal in a oil sand tailings stacking area.

15 In the Bayer process for recovery of alumina from bauxite, the bauxite is digested in an aqueous alkaline liquor to form sodium aluminate which is separated from the insoluble residue. This residue consists of both sand, and fine particles of mainly ferric oxide. The aqueous suspension of the latter is known as red mud.

20

After the primary separation of the sodium aluminate solution from the insoluble residue, the sand (coarse waste) is separated from the red mud. The supernatant liquor is further processed to recover aluminate. The red mud is then washed in a plurality of sequential washing stages, in which the
25 red mud is contacted by a wash liquor and is then flocculated by addition of a flocculating agent. After the final wash stage the red mud slurry is thickened as much as possible and then disposed of. Thickening in the context of this specification means that the solids content of the red mud is increased. The final thickening stage may comprise settlement of flocculated slurry only, or
30 sometimes, includes a filtration step. Alternatively or additionally, the mud may be subjected to prolonged settlement in a lagoon. In any case, this final

thickening stage is limited by the requirement to pump the thickened aqueous suspension to the disposal area.

5 The mud can be disposed of and/or subjected to further drying for subsequent disposal on a mud stacking area. To be suitable for mud stacking the mud should have a high solids content and, when stacked, should not flow but should be relatively rigid in order that the stacking angle should be as high as possible so that the stack takes up as little area as possible for a given volume. The requirement for high solids content conflicts
10 with the requirement for the material to remain pumpable as a fluid, so that even though it may be possible to produce a mud having the desired high solids content for stacking, this may render the mud unpumpable.

15 The sand fraction removed from the residue is also washed and transferred to the disposal area for separate dewatering and disposal.

EP-A-388108 describes adding a water-absorbent, water-insoluble polymer to a material comprising an aqueous liquid with dispersed particulate solids, such as red mud, prior to pumping and then pumping the material, allowing
20 the material to stand and then allowing it to rigidify and become a stackable solid. The polymer absorbs the aqueous liquid of the slurry which aids the binding of the particulate solids and thus solidification of the material.

However this process has the disadvantage that it requires high doses of absorbent polymer in order to achieve adequate solidification. In order to
25 achieve a sufficiently rigidified material it is often necessary to use doses as high as 10 to 20 kilograms per tonne of mud. Although the use of water swellable absorbent polymer to rigidify the material may appear to give an apparent increase in solids, the aqueous liquid is in fact held within the absorbent polymer. This presents the disadvantage that as the aqueous
30 liquid has not actually been removed from the rigidified material and under certain conditions the aqueous liquid could be desorbed subsequently and

this could risk re-fluidisation of the waste material, with the inevitable risk of destabilising the stack.

WO-A-96/05146 describes a process of stacking an aqueous slurry of
5 particulate solids which comprises admixing an emulsion of a water-soluble polymer dispersed in a continuous oil phase with the slurry. Preference is given to diluting the emulsion polymer with a diluent, and which is preferably in a hydrocarbon liquid or gas and which will not invert the emulsion. Therefore it is a requirement of the process that the polymer is not added in
10 to the slurry as an aqueous solution.

WO-A-0192167 describes a process where a material comprising a suspension of particulate solids is pumped as a fluid and then allowed to stand and rigidify. The rigidification is achieved by introducing into the
15 suspension particles of a water soluble polymer which has an intrinsic viscosity of at least 3 dl/g. This treatment enables the material to retain its fluidity as being pumped, but upon standing causes the material to rigidify. This process has the benefit that the concentrated solids can be easily stacked, which minimises the area of land required for disposal. The
20 process also has the advantage over the use of cross linked water absorbent polymers in that water from the suspension is released rather than being absorbed and retained by the polymer. The importance of using particles of water soluble polymer is emphasised and it is stated that the use of aqueous solutions of the dissolved polymer would be ineffective. Very efficient release
25 of water and convenient storage of the waste solids is achieved by this process, especially when applied to a red mud underflow from the Bayer alumina process.

However, despite the improvements brought about by WO-A-0192167,
30 particularly in the treatment of red mud and treatment of oil sands tailing, there is still a need to further improve the rigidification of suspensions of materials and further improve upon the clarity of liquor released. In particular,

an objective of the present invention is to find a more suitable method for treating coarse and/or fine particulate waste material from mineral sands, alumina, oil sands or other mineral processing operations in order to provide better release of liquor and a more effective means of disposing of the concentrated solids. Furthermore, there is a need to improve the dewatering of suspensions of waste solids that have been transferred as a fluid to a settling area for disposal and provide improvements in the clarity of run-off water. In particular, it would be desirable to provide a more effective treatment of waste suspensions transferred to disposal areas, for instance tailings dams, ensuring fast, efficient concentration and more environmentally friendly storage of solids and improve clarity of released liquor.

In one aspect of the present invention, we provide a process in which material comprising an aqueous liquid with dispersed particulate solids is transferred as a fluid to a deposition area, then allowed to stand and rigidify, and in which rigidification is improved whilst retaining the fluidity of the material during transfer, by combining with the material an effective rigidifying amount of aqueous solution of a water-soluble polymer.

20

In a preferred embodiment the dispersed particulate solids are in all or in part oil sands tailings. The dispersed particulate solids are produced from extraction of the oil or bitumen from oil sands.

25 In a second aspect of the present invention, we provide a process in which the aqueous liquid contains dispersed particulate solids with a bimodal distribution of particle sizes and following treatment with an effective amount of aqueous solution of a water soluble polymer, on standing, rigidifies without significant segregation of the coarse and fine fractions of particulate solids.

30

The addition of the aqueous solution of water-soluble polymer to the material allows it to retain sufficient fluidity during transfer and then once the material is allowed to stand it will form a solid mass strong enough to support subsequent layers of rigidified material. We have unexpectedly found that
5 the addition of the aqueous solution of polymer to the material does not cause instant rigidification or substantially any settling of the solids prior to standing.

Generally suspended solids will be concentrated in a thickener and this
10 material will leave the thickener as an underflow which will be pumped along a conduit to a deposition area. The conduit is any convenient means for transferring the material to the deposition area and may for instance be a pipe or a trench. The material remains fluid and pumpable during the transfer stage until the material is allowed to stand.

15

Desirably the process of the invention is part of the mineral or oil sands processing operation in which an aqueous suspension of waste solids is optionally flocculated in a vessel to form a supernatant layer comprising an aqueous liquor and an underflow layer comprising thickened solids which
20 form the material. The supernatant layer will be separated from the underflow in the vessel and is typically recycled or subjected to further processing. The aqueous suspension of waste solids or optionally, the thickened underflow is transferred, usually by pumping, to a deposition area, which may for instance be a tailings dam or lagoon. The material may consist of
25 only mainly fine particles, or a mixture of fine and coarse particles.

Optionally, additional coarse particles may be combined with the aqueous suspension at any convenient point prior to discharge at the deposition area. Once the material has reached the deposition area it is allowed to stand and rigidification takes place. The aqueous polymer solution may be added to the
30 material in an effective amount at any convenient point, typically during transfer. In some cases the aqueous suspension may be transferred first to a holding vessel before being transferred to the deposition area.

Suitable doses of polymer range from 10 grams to 10,000 grams per tonne of material solids. Generally the appropriate dose can vary according to the particular material and material solids content. Preferred doses are in the
5 range 30 to 3,000 grams per tonne, while more preferred doses are in the range of from 60 to 200 or 400 grams per tonne.

The material particles are usually inorganic and/or usually a mineral. For example, the material particles are sand, oil sands tailings, clay, shale, grit,
10 silt, metal oxides etc admixed with water.

Typically the material may be derived from or contain filter cake, tailings, thickener underflows, or unthickened plant waste streams, for instance other mineral tailings, oil sand tailings or slimes, including phosphate, diamond,
15 gold slimes, mineral sands, tails from zinc, lead, copper, silver, uranium, nickel, iron ore processing, coal, or red mud. The material may be solids settled from the final thickener or wash stage of a mineral or oil sands processing operation. Thus the material desirably results from a mineral or oil sands processing operation. Preferably the material comprises tailings.

20

The fine tailings or other material which is pumped may have a solids content in the range 10% to 80% by weight. The slurries are often in the range 20% to 70% by weight, for instance 45% to 65% by weight. The sizes of particles in a typical sample of the fine tailings are substantially all less
25 than 25 microns, for instance about 95% by weight of material is particles less than 20 microns and about 75% is less than 10 microns. The coarse tailings are substantially greater than 100 microns, for instance about 85% is greater than 100 microns but generally less than 10,000 microns. The fine tailings and coarse tailings may be present or combined together in any
30 convenient ratio provided that material remains pumpable.

The dispersed particulate solids may have a bimodal distribution of particle sizes. Typically this bimodal distribution may comprise a fine fraction and a coarse fraction, in which the fine fraction peak is substantially less than 25 microns and the coarse fraction peak is substantially greater than 75
5 microns.

For example, the particles in oil sands tailings may have a fine fraction of less than about 45 microns. For instance about 70 percent of the particles may be less than about 45 microns.

10

We have found better results are obtained when the material is relatively concentrated and homogenous. It may also be desirable to combine the addition of the polymer solution with other additives. For instance the flow properties of the material through a conduit may be facilitated by including a
15 dispersant. Typically where a dispersant is included it would be included in conventional amounts. However, we have found that surprisingly the presence of dispersants or other additives does not impair the rigidification of the material on standing. It may also be desirable to pre-treat the material with either an inorganic or organic coagulant to pre-coagulate the fine
20 material to aid its retention in the rigidified solids.

Thus in the present invention the polymer solution is added directly to the aforementioned material. The polymer solution may consist wholly or partially of water-soluble polymer. Thus the polymer solution may comprise a
25 blend of cross-linked polymer and water soluble polymer, provided sufficient of the polymer is in solution or behaves as though it is in solution to bring about rigidification on standing.

This may be a physical blend of swellable polymer and soluble polymer or
30 alternatively is a lightly cross-linked polymer for instance as described in EP202780. Although the polymeric particles may comprise some cross-linked polymer it is essential to the present invention that a significant

amount of water soluble polymer is present. When the polymeric particles comprise some swellable polymer it is desirable that at least 80% of the polymer is water-soluble.

- 5 Preferably the aqueous solution of polymer comprises polymer which is wholly or at least substantially water soluble. The water soluble polymer may be branched by the presence of branching agent, for instance as described in WO-A-9829604, for instance in claim 12, or alternatively the water soluble polymer is substantially linear.

10

- Preferably the water soluble polymer is of moderate to high molecular weight. Desirably it will have an intrinsic viscosity of at least 3 dl/g (measured in 1M NaCl at 25°C) and generally at least 5 or 6 dl/g, although the polymer may be of significantly high molecular weight and exhibit an intrinsic viscosity
- 15 of 25 dl/g or 30 dl/g or even higher. Preferably the polymer will have an intrinsic viscosity in the range of 8dl/g to 25 dl/g, more preferably 11 dl/g or 12 dl/g to 18 dl/g or 20 dl/g.

- The water soluble polymer may be a natural polymer, for instance
- 20 polysaccharides such as starch, guar gum or dextran, or a semi-natural polymer such as carboxymethyl cellulose or hydroxyethyl cellulose. Preferably the polymer is synthetic and preferably it is formed from an ethylenically unsaturated water-soluble monomer or blend of monomers.

- 25 The water soluble polymer may be cationic, non-ionic, amphoteric, or anionic. The polymers may be formed from any suitable water-soluble monomers. Typically the water soluble monomers have a solubility in water of at least 5g/100cc at 25°C. Particularly preferred anionic polymers are formed from monomers selected from ethylenically unsaturated carboxylic
- 30 acid and sulphonic acid monomers, preferably selected from (meth) acrylic acid, allyl sulphonic acid and 2-acrylamido-2-methyl propane sulphonic acid (AMPS), and their salts, optionally in combination with non-ionic co-

monomers, preferably selected from (meth) acrylamide, hydroxy alkyl esters of (meth) acrylic acid and N-vinyl pyrrolidone.

Preferred non-ionic polymers are formed from ethylenically unsaturated
5 monomers selected from (meth) acrylamide, hydroxy alkyl esters of (meth) acrylic acid and N-vinyl pyrrolidone.

Preferred cationic polymers are formed from ethylenically unsaturated
monomers selected from dimethyl amino ethyl (meth) acrylate - methyl
10 chloride, (DMAEA.MeCl) quat, diallyl dimethyl ammonium chloride (DADMAC), trimethyl amino propyl (meth) acrylamide chloride (ATPAC) optionally in combination with non-ionic co-monomers, preferably selected from (meth) acrylamide, hydroxy alkyl esters of (meth) acrylic acid and N-vinyl pyrrolidone.

15

In some instances, it has been found advantageous to separately add combinations of polymer types. Thus an aqueous solution of an anionic, cationic or non-ionic polymer may be added to the above mentioned material first, followed by a second dose of either a similar or different water soluble
20 polymer of any type.

In the invention, the water soluble polymer may be formed by any suitable polymerisation process. The polymers may be prepared for instance as gel polymers by solution polymerisation, water-in-oil suspension polymerisation
25 or by water-in-oil emulsion polymerisation. When preparing gel polymers by solution polymerisation the initiators are generally introduced into the monomer solution.

Optionally a thermal initiator system may be included. Typically a thermal
30 initiator would include any suitable initiator compound that releases radicals at an elevated temperature, for instance azo compounds, such as azo-bis-

isobutyronitrile. The temperature during polymerisation should rise to at least 70°C but preferably below 95°C. Alternatively polymerisation may be effected by irradiation (ultra violet light, microwave energy, heat etc.) optionally also using suitable radiation initiators. Once the polymerisation is complete and the polymer gel has been allowed to cool sufficiently the gel can be processed in a standard way by first comminuting the gel into smaller pieces, drying to the substantially dehydrated polymer followed by grinding to a powder. Alternatively polymer gels may be supplied in the form of polymer gels, for instance as neutron type gel polymer logs.

10

Such polymer gels may be prepared by suitable polymerisation techniques as described above, for instance by irradiation. The gels may be chopped to an appropriate size as required and then on application mixed with the material as partially hydrated water soluble polymer particles.

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The polymers may be produced as beads by suspension polymerisation or as a water-in-oil emulsion or dispersion by water-in-oil emulsion polymerisation, for example according to a process defined by EP-A-150933, EP-A-102760 or EP-A126528.

20

Alternatively the water soluble polymer may be provided as a dispersion in an aqueous medium. This may for instance be a dispersion of polymer particles of at least 20 microns in an aqueous medium containing an equilibrating agent as given in EP-A-170394. This may for example also include aqueous dispersions of polymer particles prepared by the polymerisation of aqueous monomers in the presence of an aqueous medium containing dissolved low IV polymers such as poly diallyl dimethyl ammonium chloride and optionally other dissolved materials for instance electrolyte and/or multi-hydroxy compounds e. g. polyalkylene glycols, as given in WO-A-9831749 or WO-A-9831748.

30

The aqueous solution of water-soluble polymer is typically obtained by dissolving the polymer in water or by diluting a more concentrated solution of the polymer. Generally solid particulate polymer, for instance in the form of powder or beads, is dispersed in water and allowed to dissolve with agitation. This may be achieved using conventional make up equipment. Desirably, the polymer solution can be prepared using the Auto Jet Wet (trademark) supplied by Ciba Specialty Chemicals. Alternatively, the polymer may be supplied in the form of a reverse phase emulsion or dispersion which can then be inverted into water.

10

The aqueous polymer solution may be added in any suitable concentration. It may be desirable to employ a relatively concentrated solution, for instance up to 10 % or more based on weight of polymer in order to minimise the amount of water introduced into the material. Usually though it will be desirable to add the polymer solution at a lower concentration to minimise problems resulting from the high viscosity of the polymer solution and to facilitate distribution of the polymer throughout the material. The polymer solution can be added at a relatively dilute concentration, for instance as low as 0.01% by weight of polymer. Typically the polymer solution will normally be used at a concentration between 0.05 and 5% by weight of polymer. Preferably the polymer concentration will be the range 0.1% to 2 or 3%. More preferably the concentration will range from 0.25% to about 1 or 1.5%.

25

In a mineral or oil sands processing operation where a suspension containing solids is flocculated in a thickener in order to separate the suspension into a supernatant layer and an underflow material, the material can typically be treated at any suitable point after flocculation in the thickener but before the material is allowed to stand. A suitable and effective rigidifying amount of the water-soluble polymer solution can be mixed with the material prior to a pumping stage. In this way the polymer solution can be distributed throughout the material. Alternatively, the polymer solution can be introduced and mixed with the material during a pumping stage or

30

- subsequently. The most effective point of addition will depend upon the substrate and the distance from the thickener to the deposition area. If the conduit is relatively short any may be advantageous to dose the polymer solution close to where the material flows from the thickener. On the other
- 5 hand, where the deposition area is significantly remote from the thickener in may be desirable to introduce the polymer solution closer to the outlet. In some instances in may be convenient to introduce the polymer solution into the material as it exits the outlet.
- 10 When aqueous suspensions of fine and coarse particulate materials are being combined for the purposes of co-disposal, the effective rigidifying amount of the water-soluble polymer solution will normally be added during or after the mixing of the different waste streams into a homogeneous slurry.
- 15 Preferably the material will be pumped as a fluid to an outlet at the deposition area and the material allowed to flow over the surface of rigidified material. The material is allowed to stand and rigidify and therefore forming a stack of rigidified material. This process may be repeated several times to form a stack that comprises several layers of rigidified material. The
- 20 formation of stacks of rigidified material has the advantage that less area is required for disposal.

The rheological characteristics of the material as it flows through the conduit to the deposition area is important, since any significant reduction in flow

25 characteristics could seriously impair the efficiency of the process. It is important that there is no significant settling of the solids as this could result in a blockage, which may mean that the plant has to be closed to allow the blockage to be cleared. In addition it is important that there is no significant reduction in flow characteristics, since this could drastically impair the

30 pumpability on the material. Such a deleterious effect could result in significantly increased energy costs as pumping becomes harder and the likelihood of increased wear on the pumping equipment.

The rheological characteristics of the material as it rigidifies is important, since once the material is allowed to stand it is important that flow is minimised and that solidification of the material proceeds rapidly. If the material is too fluid then it will not form an effective stack and there is also a risk that it will contaminate water released from the material. It is also necessary that the rigidified material is sufficiently strong to remain intact and withstand the weight of subsequent layers of rigidified material being applied to it.

Preferably the process of the invention will achieve a heaped disposal geometry and will co-immobilise the fine and course fractions of the solids in the material and also allowing any released water to have a higher driving force to separate it from the material by virtue of hydraulic gravity drainage.

The heaped geometry appears to give a higher downward compaction pressure on underlying solids which seems to be responsible for enhancing the rate of dewatering. We find that this geometry results in a higher volume of waste per surface area, which is both environmentally and economically beneficial.

It is not possible to achieve the objectives of the invention by adapting the flocculation step in the thickener. For instance flocculation of the suspension in the thickener to provide an underflow sufficiently concentrated such that it would stack would be of a little value since it would not be possible to pump such a concentrated underflow. Instead we have found that it is essential to treat the material that has been formed as an underflow in the thickener. It appears that separately treating the thickened solids in the underflow allows the material to rigidify effectively without compromising the fluidity during transfer.

A preferred feature of the present invention is the release of aqueous liquor that often occurs during the rigidification step. Thus in a preferred form of the

invention the material is dewatered during rigidification to release liquor containing significantly less solids. The liquor can then be returned to the process thus reducing the volume of imported water required and therefore it is important that the liquor is clear and substantially free of contaminants, especially migrating particulate fines. Suitably the liquor may for instance be recycled to the thickener from which the material was separated as an underflow. Alternatively, the liquor can be recycled to the spirals or other processes within the same plant.

Furthermore clarifying polymers may optionally be added after the thickener to the underflow but before disposal by rigidification. This may enhance the clarity of the water released from the rigidifying stack.

The clarifying polymers are typically low molecular weight, polymers.

For the purposes of the invention low molecular weight means an average molecular weight ranging from about 10,000 to about 1,000,000 g/mol. For example, anionic polymers in the range of about 10,000 to about 500,000 g/mol may be used.

These can be anionic, non-ionic or cationic. They can be synthetic or naturally derived, eg from starch, gums or cellulose, eg carboxymethyl cellulose. Preferably they are anionic, eg a homopolymer of sodium acrylate, or as a copolymer with acrylamide, or hydrolysed polyacrylonitrile or hydrolysed acrylamide.

25

The amount of clarifying polymer will be determined by the composition of the oil sands tailings but generally about 5 to about 500 g/tonne of dry solids. For example the amount of clarifying polymer may be about 5 g to about 100 g/tonne of dry solids.

30

The clarifying polymer may be added as a solution or powder and may be added in any suitable concentration. It may be desirable to employ a relatively concentrated solution, for instance up to 10 % or more based on weight of polymer in order to minimise the amount of water introduced into the material. The clarifying polymer solution can be added at a relatively dilute concentration, for instance as low as 0.01% by weight of polymer. Typically the clarifying polymer solution will normally be used at a concentration between 0.05 and 5% by weight of polymer. Preferably the polymer concentration will be the range 0.1% to 2 or 3%. More preferably the concentration will range from 0.25% to about 1 or 1.5%.

The clarifying polymer may be added before, simultaneously, or after the rigidifying amount of the water-soluble polymer solution.

It is equally possible to treat the tailings without the thickener step if the feed is at a sufficiently high solids concentration and suitable sands/ fines ratio.

In a further aspect of the present invention we provide a process in which material comprising an aqueous liquid with dispersed particulate solids is transferred as a fluid to a settling area, then allowed to dewater to release liquor containing dissolved mineral values, and in which dewatering is improved whilst retaining the fluidity of the material during transfer, by combining with the material an effective dewatering amount of aqueous solution of a water-soluble polymer.

25

In this form of the invention the aqueous polymer solution is applied to the material in a similar manner as described above. In this case, the polymer solution is applied in an effective dewatering amount and in the same way as a first aspect of the invention it is important that the fluidity of the material is retained during transfer. The material is transferred to a settling area, which can for instance be a tailings dam or a lagoon. The dewatering step must

proceed as quickly as possible such that the solids are allowed to concentrate and aqueous liquor is released. It is important that the liquor is of high clarity and not contaminated by solids, particularly fines, which would impair further processing.

5

Typically in a mineral or oil sands processing operation, a suspension of solids is flocculated in a vessel to form a supernatant layer comprising an aqueous liquor and an underflow layer comprising thickened solids, which forms the material. The underflow-suspension flows from the vessel, is
10 optionally combined with additional coarse particulate material, and in which the material is then pumped to a settling area where it is allowed to dewater. The aqueous polymer solution is mixed into the material after flocculating the suspension and before the material is allowed to rigidify and dewater.

15 The aqueous polymer solution may comprise any of the polymers and be used in a similar manner as that described above.

The following examples are intended to demonstrate the invention.

EXAMPLE 1

Polymer preparation

The polymer samples shown in Table 1 have been prepared by the gel polymerisation method. The polymers were stirred into water to provide an aqueous solution at a concentration of 0.25%.

Table 1

Sample	Polymer (% wt/wt)	Intrinsic Viscosity (dl/g)
A	100% acrylamide homopolymer	16
B	15/85 sodium acrylate/acrylamide copolymer	18
C	30/70 sodium acrylate/acrylamide copolymer	12
D	30/70 sodium acrylate/acrylamide copolymer	24
E	45/55 sodium acrylate/acrylamide copolymer	16
F	75/25 sodium acrylate/acrylamide copolymer	19
G	100% sodium acrylate homopolymer	18
H	10/90 sodium AMPS/acrylamide copolymer	16
I	40/60 sodium AMPS/acrylamide copolymer	14
J	25/75 DMAEA.MeCl/acrylamide copolymer	14
K	60/40 DMAEA.MeCl/acrylamide copolymer	12
L	80/20 DMAEA.MeCl/acrylamide copolymer	12
M	35/60/5 DMAEA.MeCl/acrylamide/sodium acrylate polymer	20

Experimental Details

Test were carried out according to the following procedures using a tailings slurry obtained from a mineral sands operation.

Table 2

Solids Content (% wt/wt)	53.1
Solids < 75 um (% wt/wt)	10.9
Specific Gravity	1.51

A) A Slump Test is conducted using the following method:

1. A collar, measuring in equal diameter and external diameter was placed on a metal surface of adequate size, with drainage holes to facilitate the collection of free water.
2. This collar is filled with the aqueous mineral slurry to the brim and levelled off.
3. The collar is lifted vertically off the tray, at speed, allowing the slurry to slump outwards.
4. The diameter of the resultant solids and the height, both at the edge and in the centre, is then recorded, allowing the height to be calculated as a percentage of the radius, denoted as the slump.

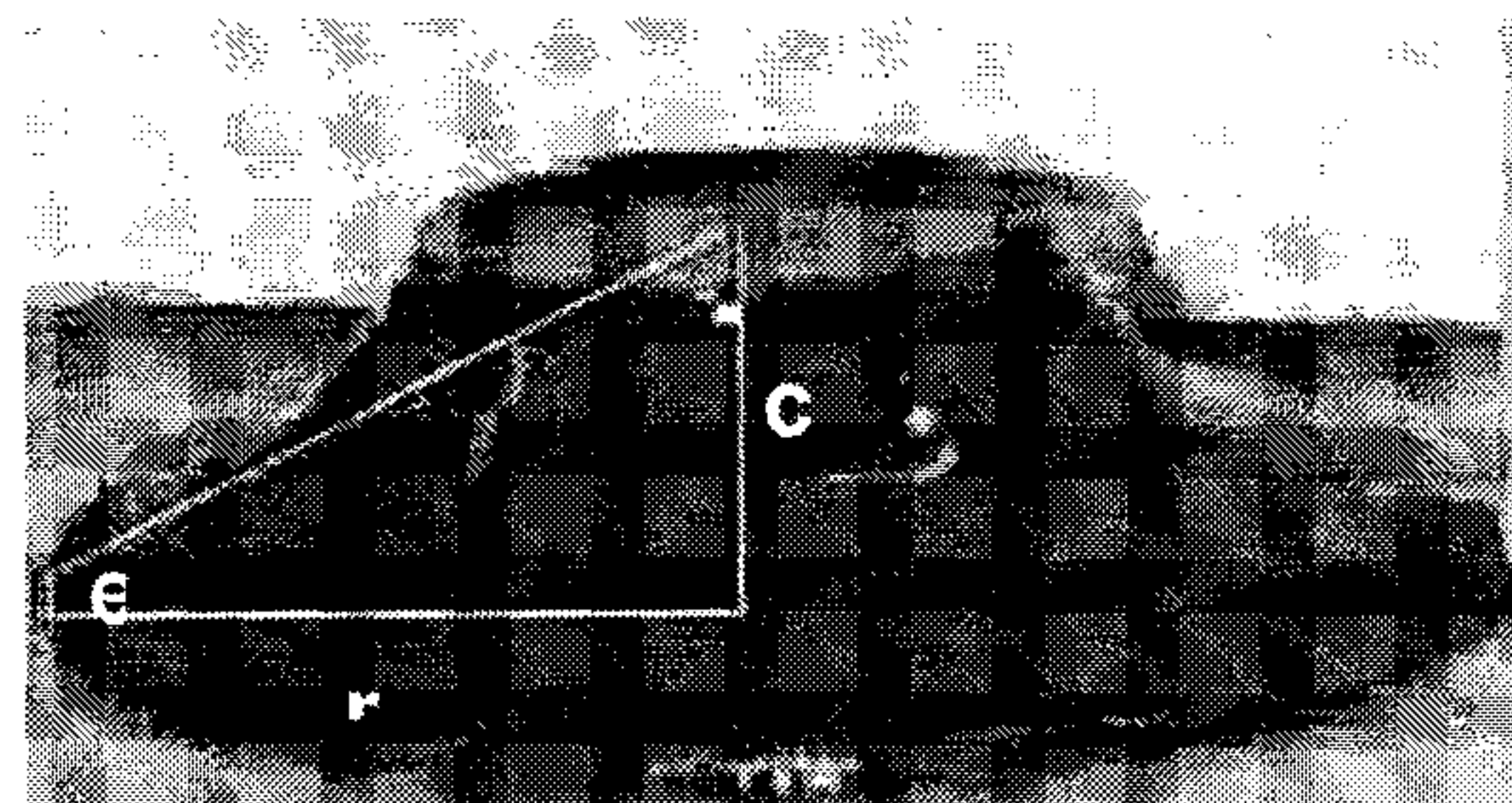
$$\text{slump (\%)} = \frac{(c - e)}{r} \times 100$$

where:

c = slump height at centre

e = slump height at edge

r = radius



5. Where applicable, the water released from the solids over a period of one minute is collected and both the volume and clarity or turbidity measured.

B) Treatment tests, employing samples A to M above were conducted using the following method.

1. A known volume of the tails slurry was sampled into an adequate size plastic beaker.

2. The slurry was then subjected to low shear mixing by pouring the sample from one beaker to another to ensure that the sample was homogeneous.
3. The required dose of aqueous polymer solution was added to the tailings slurry and mixing continued until a consistent material was produced.
4. The treated slurry was evaluated using the slump test as described in section "A" above.

Table 3

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	80	4	3	1	25	> 1000
A	125	24	52	14	158	95	23
	250	33	32	13	58	89	57
B	125	28	41	16	89	43	23
	250	23	52	6	200	46	116
C	62	28	42	17	89	57	23
	125	24	51	22	121	25	24
D	62	30	41	17	80	50	19
	125	25	47	18	116	54	20
E	62	30	38	18	67	27	72
	125	24	50	13	154	61	179
F	62	38	27	12	39	47	119
	125	23	51	27	104	56	51
G	125	25	50	18	128	57	25
	250	23	51	22	126	47	95
H	125	35	33	12	60	41	119
	250	24	52	19	138	71	69
I	62	48	23	6	35	45	108
	125	24	53	10	179	85	29
J	125	58	13	4	16	45	547
	250	23	53	21	139	80	21
K	125	25	49	19	120	52	14
	250	24	52	19	138	75	14

L	62	40	25	7	45	35	117
	125	23	51	20	135	68	20
M	125	34	33	15	53	51	208
	250	25	51	18	132	60	108

The increased rigidification of the mineral tailings through the addition of the water soluble polymer is evident by the reduced slump radius and increased stacking height compared to the untreated material. In almost all tests,

5 increases in the quantity, and significant increases in the clarity of the released liquor are also observed.

EXAMPLE 2

Polymer preparation

The polymer samples shown in Table 1 have been prepared by a number of

10 different polymerisation methods. The polymers were stirred into water to provide an aqueous solution at a concentration of 0.25% active polymer.

Table 4

Sample	Form	Polymer (% wt/wt)	Intrinsic Viscosity (dl/g)
N	Bead	30/70 sodium acrylate/acrylamide copolymer	12
O	Inverse Emulsion	30/70 sodium acrylate/acrylamide copolymer	17
P	Dispersion	30/70 sodium acrylate/acrylamide copolymer	16
Q	Solution	100% mannich derivatised polyacrylamide	14
R	Inverse Emulsion	25/75 DMAEA.MeCl/acrylamide copolymer	16
S	Bead	25/75 DMAEA.MeCl/acrylamide copolymer	8
T	Dispersion	80/20 DMAEMA.MeCl/acrylamide copolymer	8
U	Gel	5/95 APTAC/acrylamide copolymer	16
V	powder	polyethylene oxide	n/a
W	solution	dextran polysaccharide	n/a
X	powder	guar gum	n/a

Experimental Details

Tests were carried out according to the procedures and using the tailings slurry detailed in example 1.

Table 5

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	83	4	2	2	10	> 1000
N	62	28	37	12	89	38	23
	125	23	52	16	157	73	31
O	44	40	28	9	48	38	181
	87	24	54	51	13	60	44
P	62	23	52	7	196	36	124
	125	24	53	51	8	40	48
Q	55	48	22	6	33	52	285
	90	25	49	21	112	76	26
R	175	29	39	17	76	44	32
	350	24	51	23	117	52	158
S	125	48	22	7	31	36	124
	250	26	50	26	92	57	10
T	125	30	38	17	70	38	34
	250	23	52	40	52	44	72
U	250	29	37	19	62	33	24
	375	24	53	23	125	71	18
V	250	29	39	15	83	53	29
	500	28	34	15	68	32	113
W	375	65	10	5	8	35	271

5

EXAMPLE 3

Sample C from example 1 was tested according to the procedures and using the tailings slurry detailed in example 1 in conjunction with some additives which may be added to the slurry for other purposes.

10 Table 6

Sample	Additive
--------	----------

26

X	organic coagulant - poly DADMAC
Y	inorganic coagulant - poly aluminium chloride
Z	organic dispersant - sodium polyacrylate

Table 7

Sample	Dose (gpt)	Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)
Blank	0	Blank	0	93	7	3	4
X	250	C	94	23	52	29	100
C	94	X	250	24	51	26	104
Y	250	C	94	28	43	11	114
C	94	Y	250	30	45	17	93
Z	250	C	125	23	49	19	130
C	125	Z	250	23	51	21	130
J	62	C	62	28	43	15	100
C	62	J	62	23	51	26	109

EXAMPLE 4

- 5 Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a tailings slurry obtained from a lateritic nickel, acid leach process.

Table 8

Solids Content (% wt/wt)	26.7
Solids < 75 um (% wt/wt)	22.5
Specific Gravity	1.21

Results

Table 9

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	> 100	2	n/a	< 0.5	44	> 1000
A	330	80	11	3	10.0	59	> 1000
	495	50	17	6	22.0	69	169
	660	30	34	17	56.7	100	49
C	330	68	11	3	11.8	38	369
	495	30	29	15	46.7	70	82
	660	25	47	44	12.0	98	40
E	330	58	11	4	12.1	45	1000
	660	25	43	23	80.0	92	27

EXAMPLE 5

- 5 Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a red mud tailings slurry obtained from a alumina refinery.

Table 10

Solids Content (% wt/wt)	27.4
Solids < 75 um (% wt/wt)	26.7
Specific Gravity	1.25

Results

Table 11

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	85	2	n/a	< 0.5	240	> 1000
C	874	83	5	4	0.6	10	> 1000
E	292	45	19	8	24.4	55	800
	438	48	16	7	18.8	19	604
	729	63	12	5	11.1	35	NT
F	584	73	8	3	6.8	19	> 1000
	720	34	31	17	41.2	80	349
	875	31	28	13	48.4	97	233
	1022	31	32	12	64.5	92	222
J	583	68	12	5	10.3	91	> 1000
	874	45	17	8	20.0	79	950
W	874	47	16	3	27.7	29	143

EXAMPLE 6

- 5 Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a tailings slurry obtained from a gold CIL/CIP processing operation

Table 12

Solids Content (% wt/wt)	53.3
Solids < 75 um (% wt/wt)	35.4
Specific Gravity	1.58

Results

Table 13

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	> 100	2	n/a	< 0.5	22	> 1000
A	119	49	14	7	14.3	32	38
	238	52	12	7	9.6	48	95
	356	45	18	7	24.4	20	266
C	238	40	22	8	35.0	20	256
	356	28	38	21	60.7	28	42
F	238	39	22	8	35.9	18	497
	356	25	40	23	68.0	45	22
J	119	39	22	8	35.9	18	497
	238	25	40	23	68.0	45	22
	356	39	22	8	35.9	18	497

EXAMPLE 7

- 5 Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a tailings slurry obtained from a lead/zinc mineral processing operation.

Table 14

Solids Content (% wt/wt)	53.4
Solids < 75 um (% wt/wt)	45.8
Specific Gravity	1.52

Results

Table 15

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Turbidity (NTU)
Blank	0	104	5	4	1.0	0	n/a
A	123	95	6	3	3.2	0	n/a
	246	93	6	4	2.2	0	n/a
	370	83	7	4	3.6	0	n/a
C	62	85	7	4	3.5	0	n/a
	123	63	13	7	9.5	0	n/a
	246	45	20	9	24.4	0	n/a
	370	34	29	24	14.7	0	n/a
E	62	98	6	4	2.0	0	n/a
	123	93	6	4	2.2	0	n/a
	246	57	9	7	3.5	0	n/a
	370	35	29	18	31.4	0	n/a

EXAMPLE 8

- 5 Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a tailings slurry obtained from a coal preparation plant. Due to the low solids of content of this sample, the slump cylinder size was increased to 50 mm diameter x 100 mm height and 500 ml aliquots of substrate used. A clarity wedge was also used to assess the
- 10 clarity of the released water.

Table 16

Solids Content (% wt/wt)	18.5
Solids < 75 um (% wt/wt)	10.9
Specific Gravity	1.09

Results

Table 17

Sample	Dose (gpt)	r (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Volume (ml)	Clarity (0-48)
Blank	0	> 100	2	n/a	< 0.5	46	0
A	124	> 100	3	n/a	< 0.5	163	43
	371	53	16	10	11.3	290	> 48
	494	29	44	36	27.6	300	> 48
C	124	40	22	10	30.0	285	48
	247	34	33	19	41.2	315	47
	371	26	45	40	19.2	300	45
E	124	33	31	14	51.5	290	> 48
	247	30	40	25	50.0	320	47
	371	29	41	26	51.7	300	47

EXAMPLE 9

5 Laboratory Evaluation

Product 1 is an inverse emulsion containing a 80/20 sodium acrylate/acrylamide copolymer.

Product 1 was inverted into water to provide an aqueous solution containing 0.35% active polymer. The product was evaluated on a combination of fine
10 and coarse tailings from a mineral sands operation according to the methods outlined in Example 1 above.

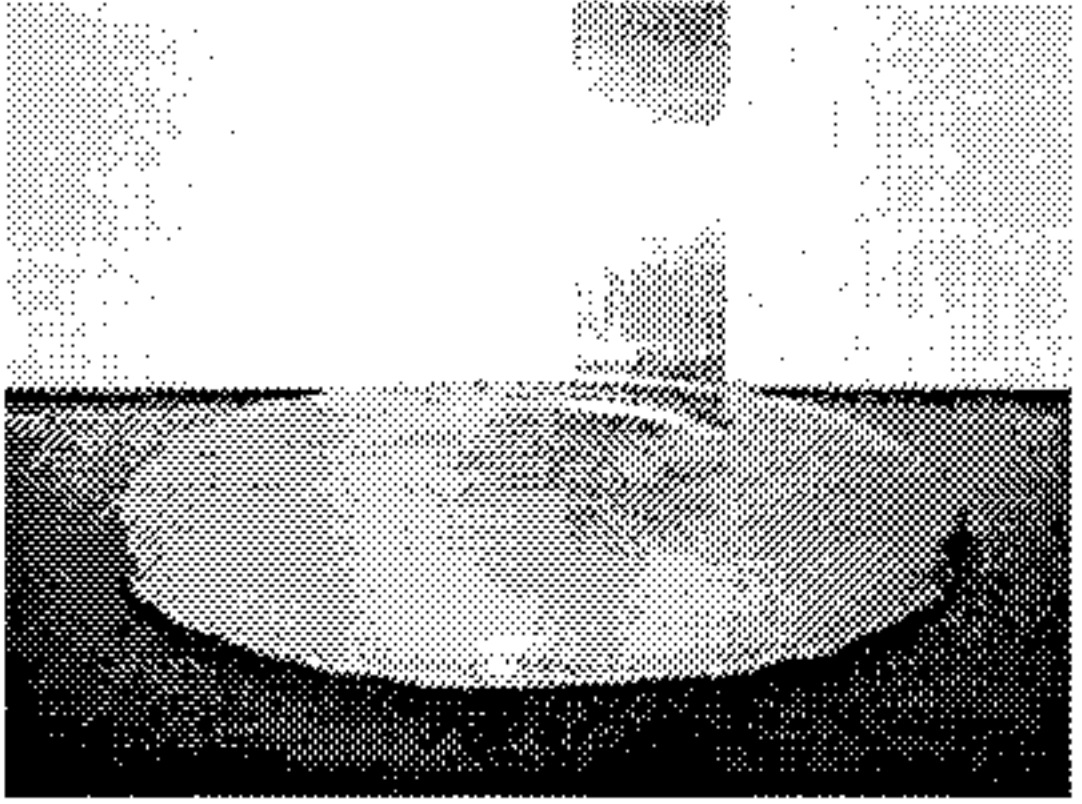
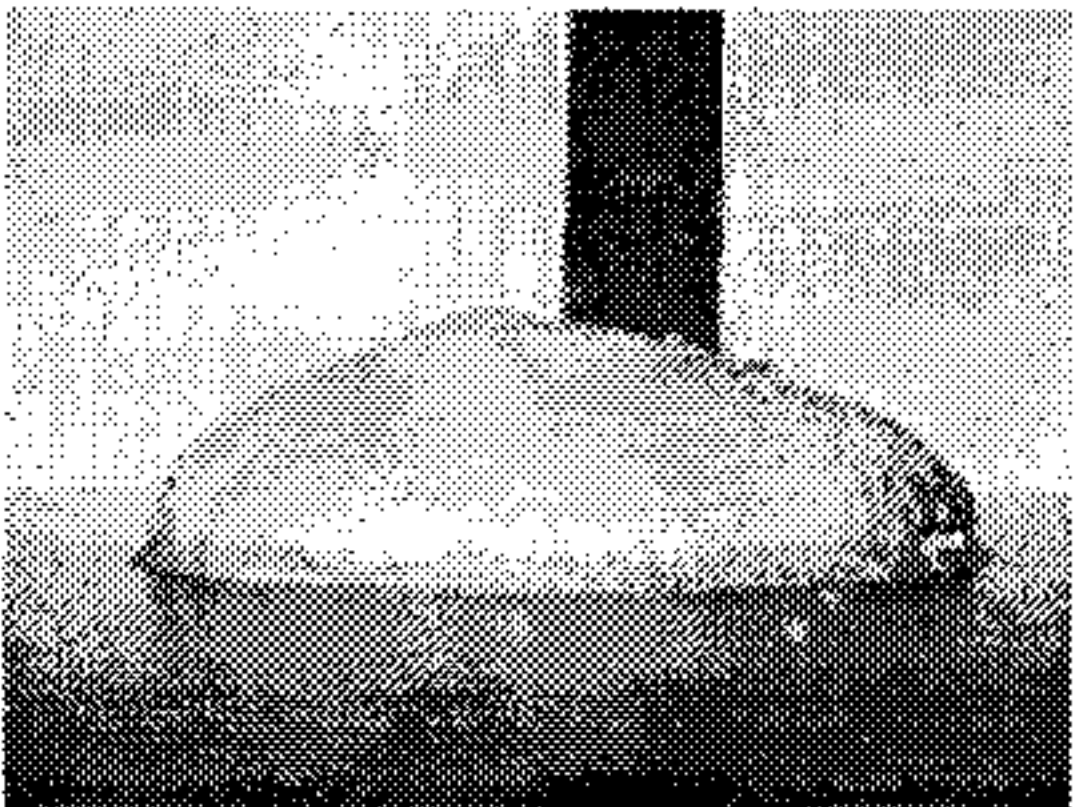
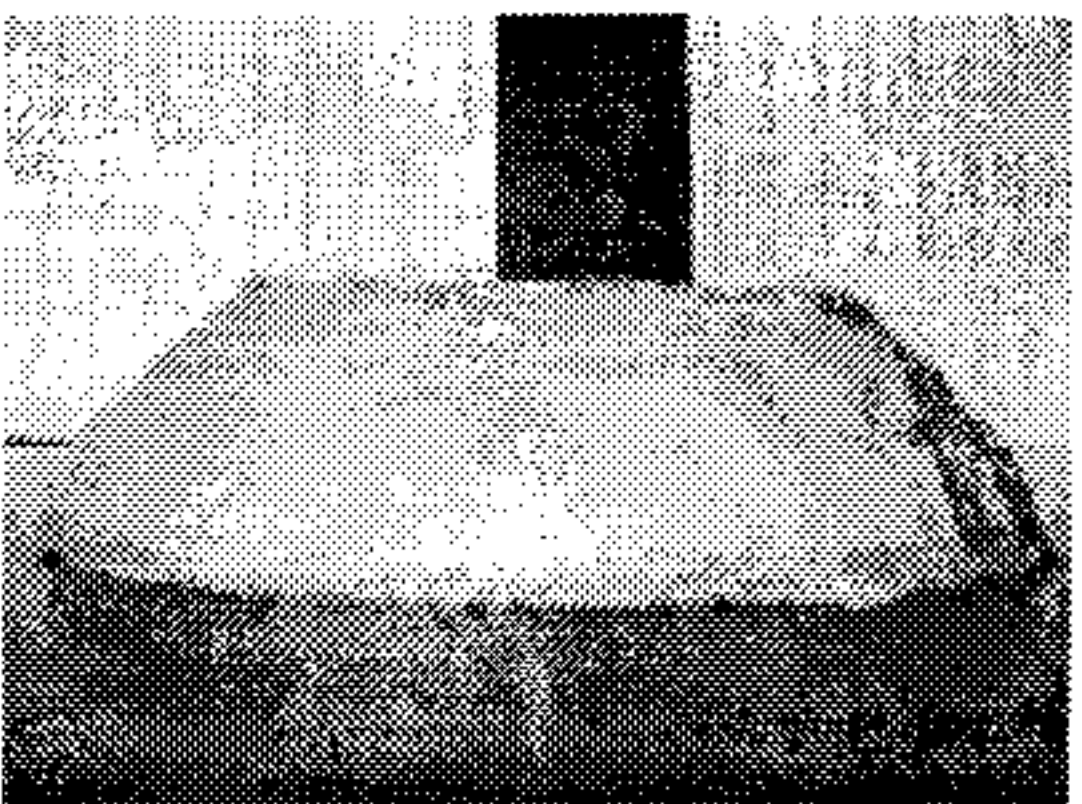
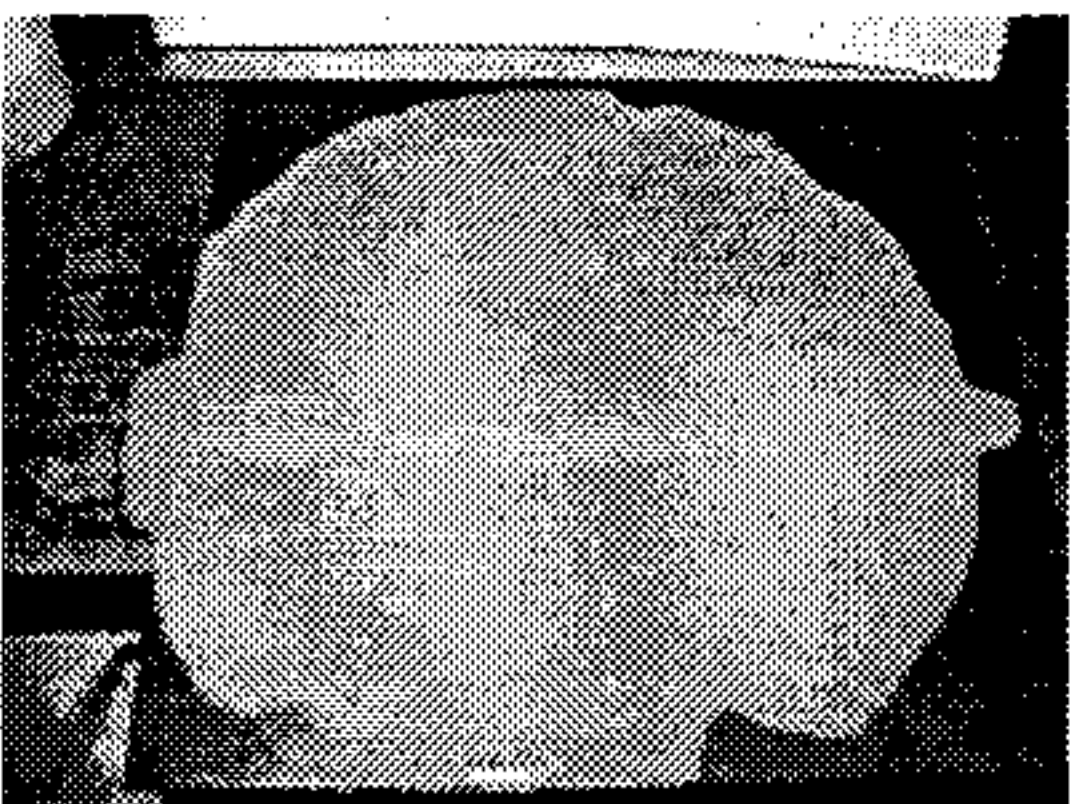
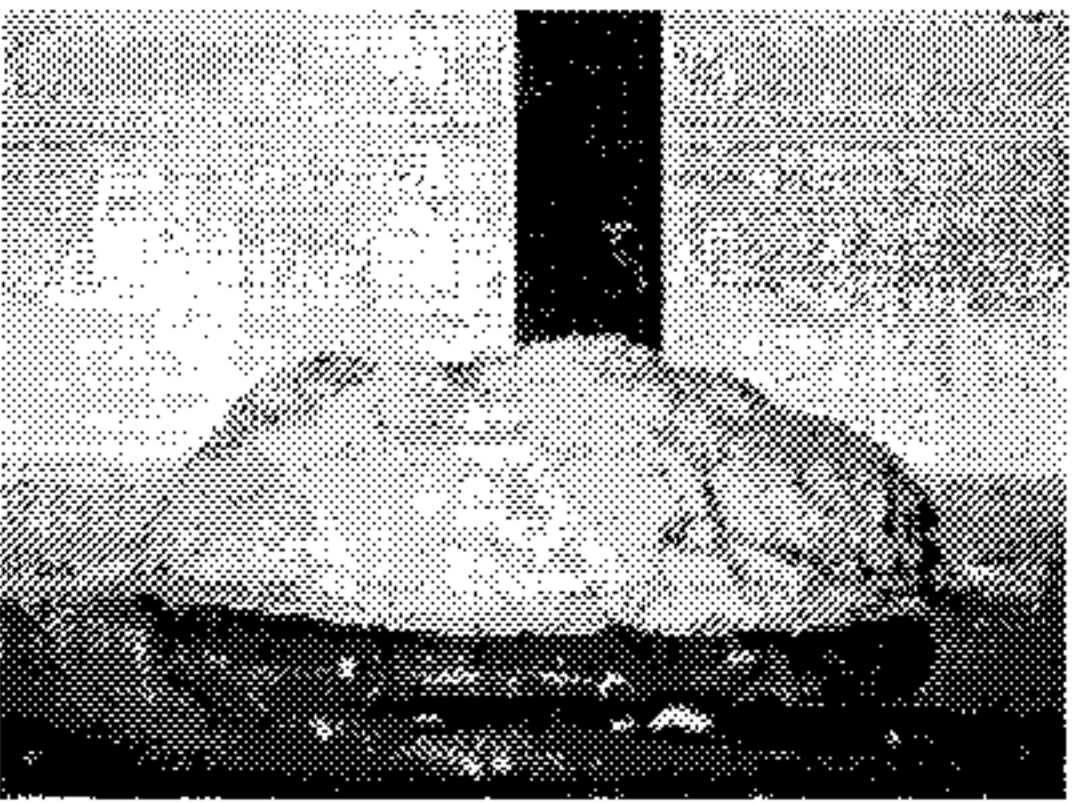
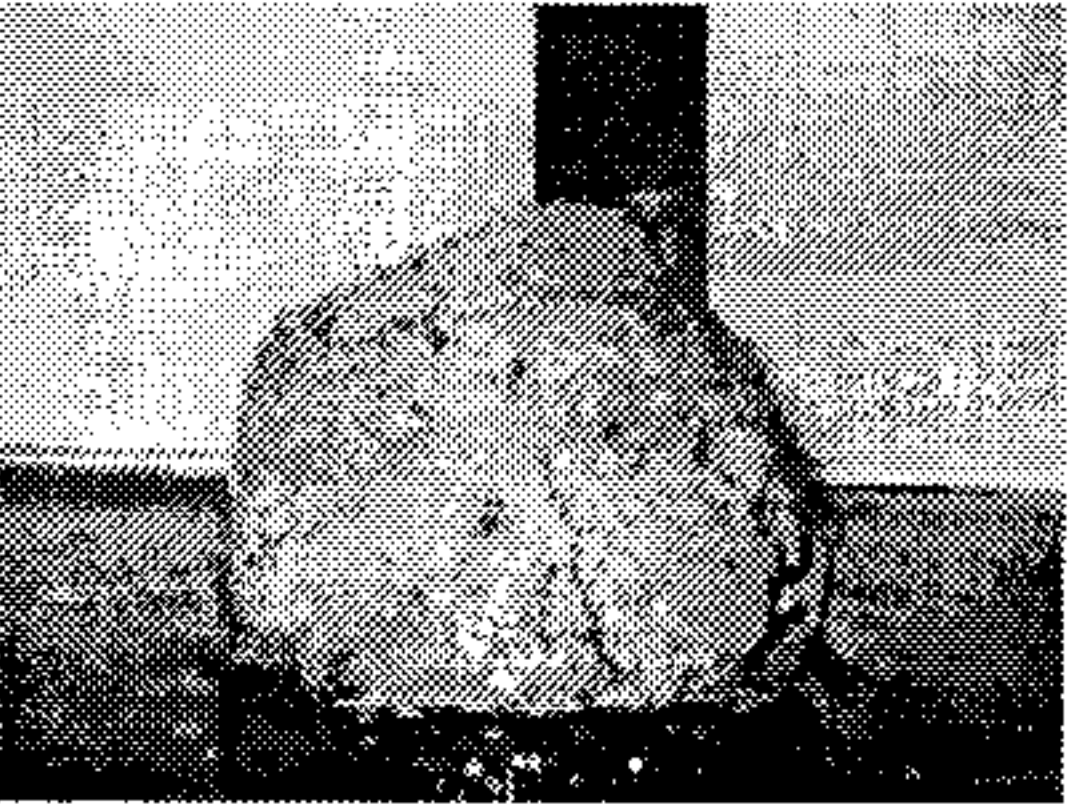
Fine solids fraction: thickener underflow @ 27.7% wt/wt

Coarse solids fraction: cyclone rejects @ 96.4% wt/wt

Where possible, the blend of coarse and fine solids were diluted with water
15 to a target solids of 43 - 47% wt/wt.

Results

Table 18

Fine & Coarse Ratio	Total Solids (% wt/wt)	Product Dose (gpt)	"r" radius (mm)	"c" Height (mm)	Photograph
1:0	28	0	110	15	not available
		181	110	11	not available
		361	85	21	not available
		542	90	21	not available
1:1	43	0	105	14	
		181	110	21	
		271	95	23	
1:2	45	0	> 200	< 5	
		120	85	23	
		302	60	47	

The photographs show the improved stacking of the treated compared to the untreated tailings. This is especially true for co-disposal of coarse and fine material with higher proportions of the coarse fraction.

EXAMPLE 10

- 5 Product 2A is an gel product consisting of a 30/70 sodium acrylate/acrylamide copolymer.

Product 2A was dissolved into water to provide an aqueous solution containing 0.25 % product as supplied. The polymer was evaluated on a combined fine and coarse tailings from a coal preparation operation at a
10 dosage of 740 gpt. The total solids content of the combined tails was approximately 19% wt/wt and approximately 1.4:1 fines/coarse ratio.

Treatment tests, employing the solution of Product 2B, were conducted using the following method:

1. 500 ml of the tails slurry was sampled into a 600 ml plastic beaker.
- 15 2. The slurry was then subjected to low shear mixing by pouring the sample from one 600 ml beaker to another to ensure that the sample was homogeneous.
3. The required dose of aqueous polymer solution was added to the tailings slurry and mixing continued until a consistent material was produced.
- 20 4. The material was transferred into a 500 ml measuring cylinder and left to compact for several days, after which the liberated water was decanted and discarded.
5. Sections were taken from the top and the bottom of the compacted solids and analysed to determine the particle size distribution of the solids in
25 each section.

Results

The particle size distribution in each section are represented graphically in Figure's 1 and 2.

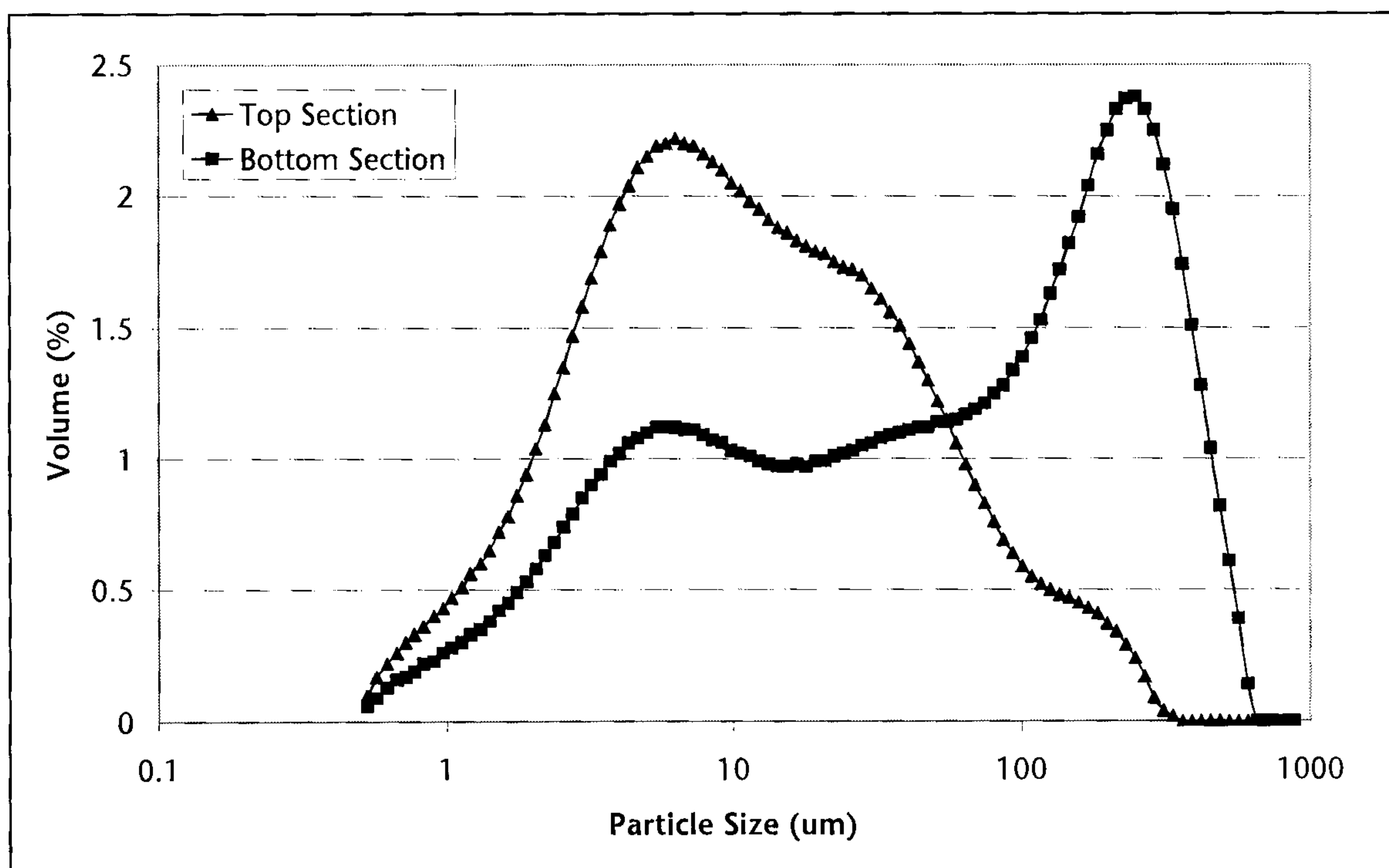


Figure 1: Untreated Coal Tailings

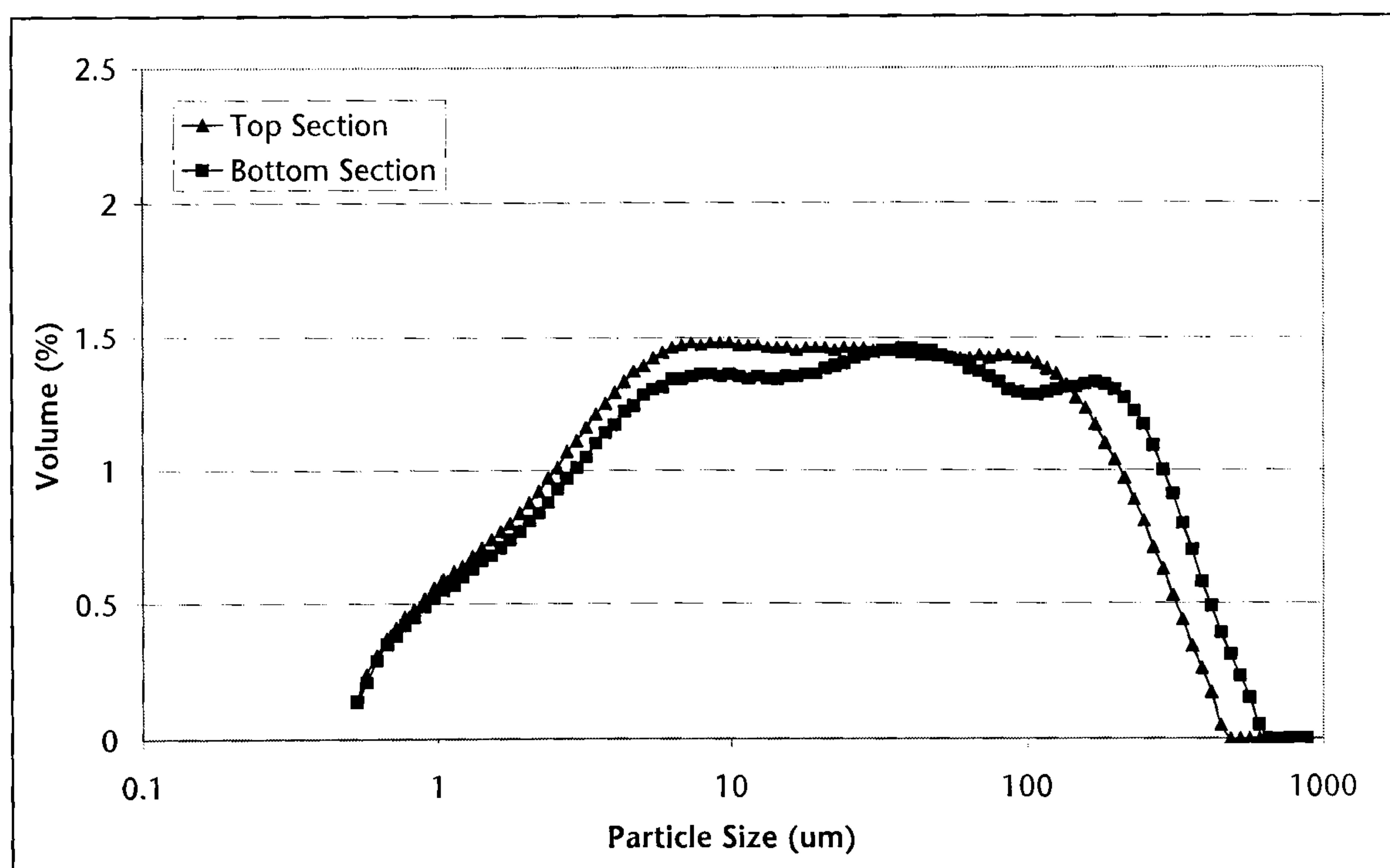


Figure 2: Treated Coal Tailings - 740 gpt of Polymer 2A

Figure 1 shows that for the untreated material, a high degree of segregation in the compacted solids has occurred with the majority of the coarse particles only present in the bottom section of the sample. Figure 2 shows that for the material treated with 740 gpt of Polymer 2A, the particle size distributions in both the top and the bottom sections are very similar, and only minimal segregation has occurred during compaction.

EXAMPLE 11

Product 2A was evaluated according to the procedures detailed in example 10 on a combined fine and coarse tailings from a gold CIL/CIP processing operation at a dosage of 240 gpt. The total solids content of the combined tails was approximately 53% wt/wt with approximately 2:1 fines/coarse ratio.

Results

The particle size distribution in each section are represented graphically in Figure's 3 and 4.

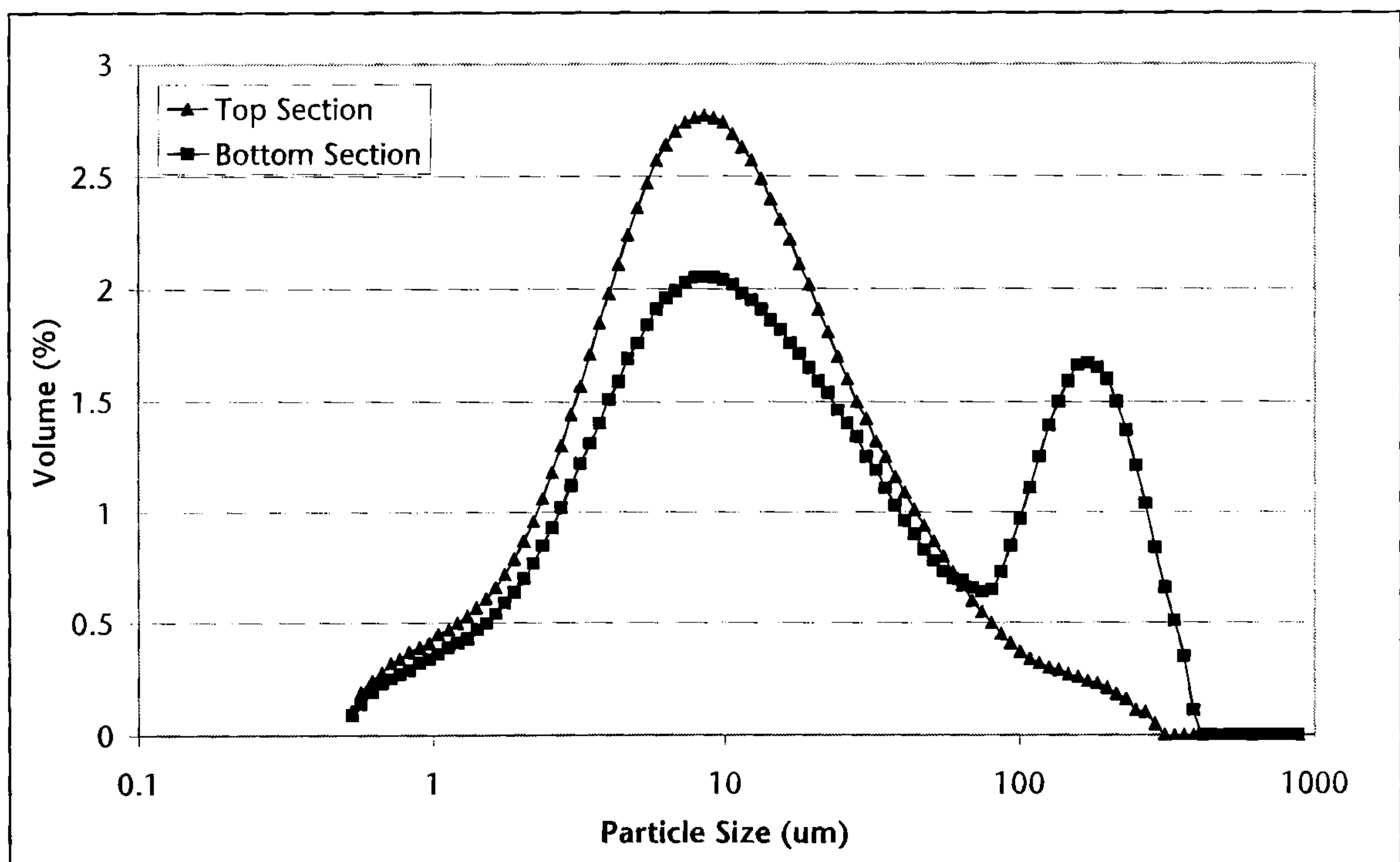


Figure 3: Untreated Gold Tailings

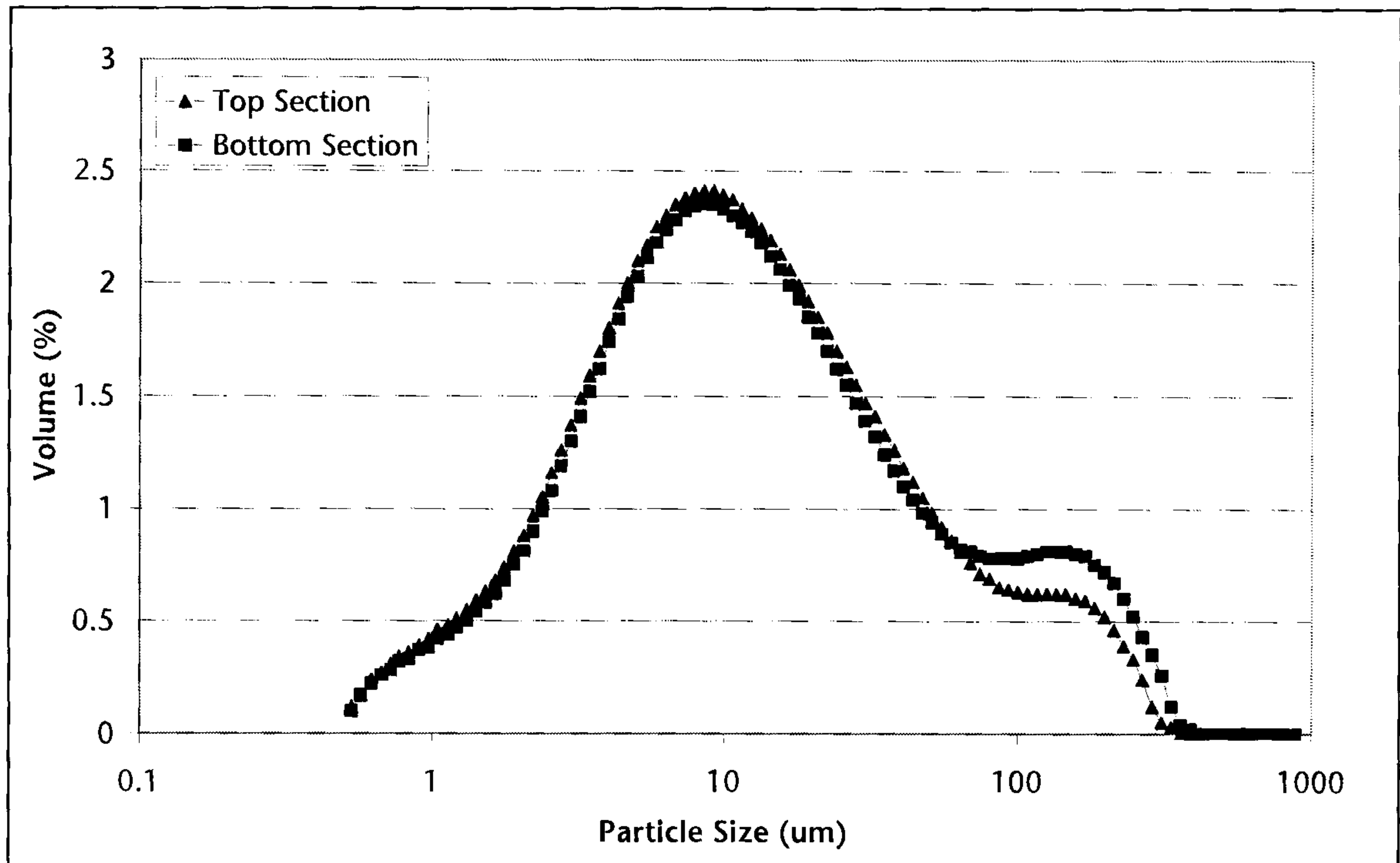


Figure 4: Treated Gold Tailings - 240 gpt of Polymer 2A

Figure 3 shows a high degree of segregation of the coarse solids to the bottom section for the untreated material where as for the material treated with Polymer 2A, Figure 4 shows that the top and bottom sections contain similar amounts of both coarse and fine particles.

EXAMPLE 12

Product 2B is an inverse emulsion containing a 30/70 sodium acrylate/acrylamide copolymer.

Product 2B was inverted into water to provide an aqueous solution containing 1.0% product as supplied. The polymer was evaluated on a combined fine and coarse tailings from a mineral sands operation. The total solids content of the combined tails was 53% wt/wt with a fines/coarse ratio of approximately 1:5.

Laboratory Evaluation

Treatment tests, employing the solution of Product 2B, were conducted using the following method:

1. Tails slurry is sampled into a 1 litre plastic bottle up to the graduation mark.
2. The slurry is then subjected to high shear mixing of ~1500rpm using an overhead stirrer and a suitably machined marine impellor, in order to produce a vortex.
3. The required amount of polymer solution is added to the vortex of the slurry created by the high shear mixing.
4. The contents of the plastic bottle is allowed to mix for 1 minute.
5. After this period had elapsed, slurry is sampled into 250ml plastic bottles, full to the neck, and these are subsequently tumbled at 25rpm for X minutes.
6. At the appropriate times, Slump tests are carried out as per Example 1.

Results

15 Table 19

Product	Dose Rate (gpt)	Mixing Time (min)	Slump Radius (mm)	Slump (%)
Blank	0	5	146	0
		10	152	0
		15	145	0
Product 2B	50	5	80	12.5
		10	85	7.1
		15	130	0.4
	100	5	45	53.3
		10	73	13.8
		15	90	2.8
	150	5	35	97.1
		10	48	50.5
		15	83	8.5

Plant Evaluation

The tails from the Mineral Sands process is pumped uphill out of the lagoon-covered mining area to a raised tailings disposal area. The low viscosity of the waste stream together with the high flow rates means that solids are
5 deposited over a great distance, and a long way from the discharge point. Scouring by the tailings stream also creates deep channelling in the disposal area. The fluidity of the flow endangers the operation of the mine since at maximum flows, the tails can flow back down into the mining area, swamping the lagoon and interfering with mining efficiency.

10

The application of this invention via the introduction of a 0.5% (as supplied) aqueous solution of a 30% anionic inverse emulsion polymer (Product 2B), at a dosage of 100g/tonne of dry solids, into the pipeline feeding a mixed fines (thickener underflow) and coarse rejects slurry fractions at a rate of 20
15 and 50 lps respectively to the disposal area. Based on the above laboratory evaluation, a dosing point close (20 meters or 11 seconds) to the discharge point was chosen to minimise shearing of the treated material. This achieved a heap of treated material with a stacking angle of 8-10 degrees (measured using a surveyors inclinometer), clean water release and samples from the
20 stack showing a high sub 75 micron content confirming a retention of the fine material within the heap disposal.

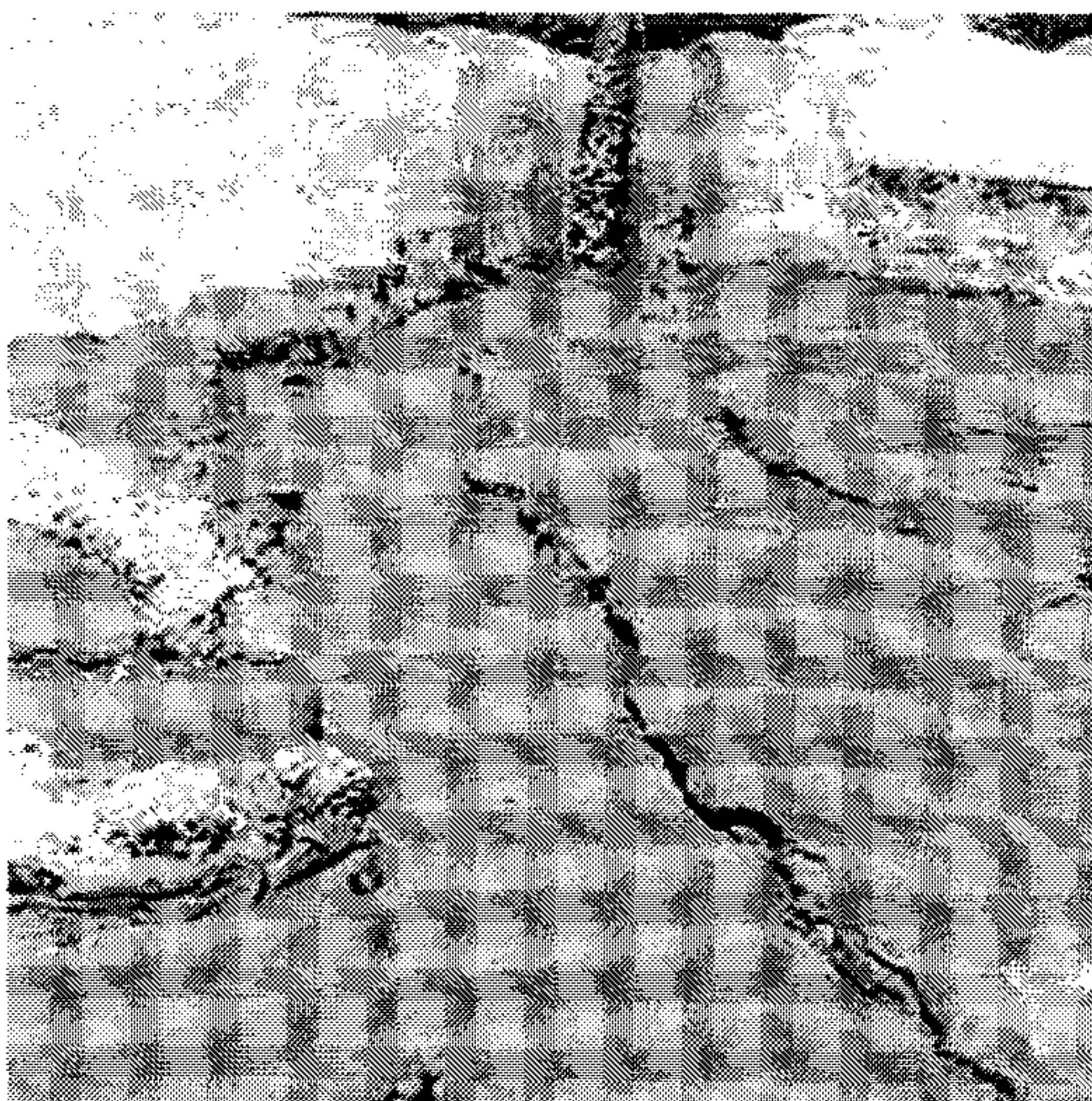


Figure 5: Untreated

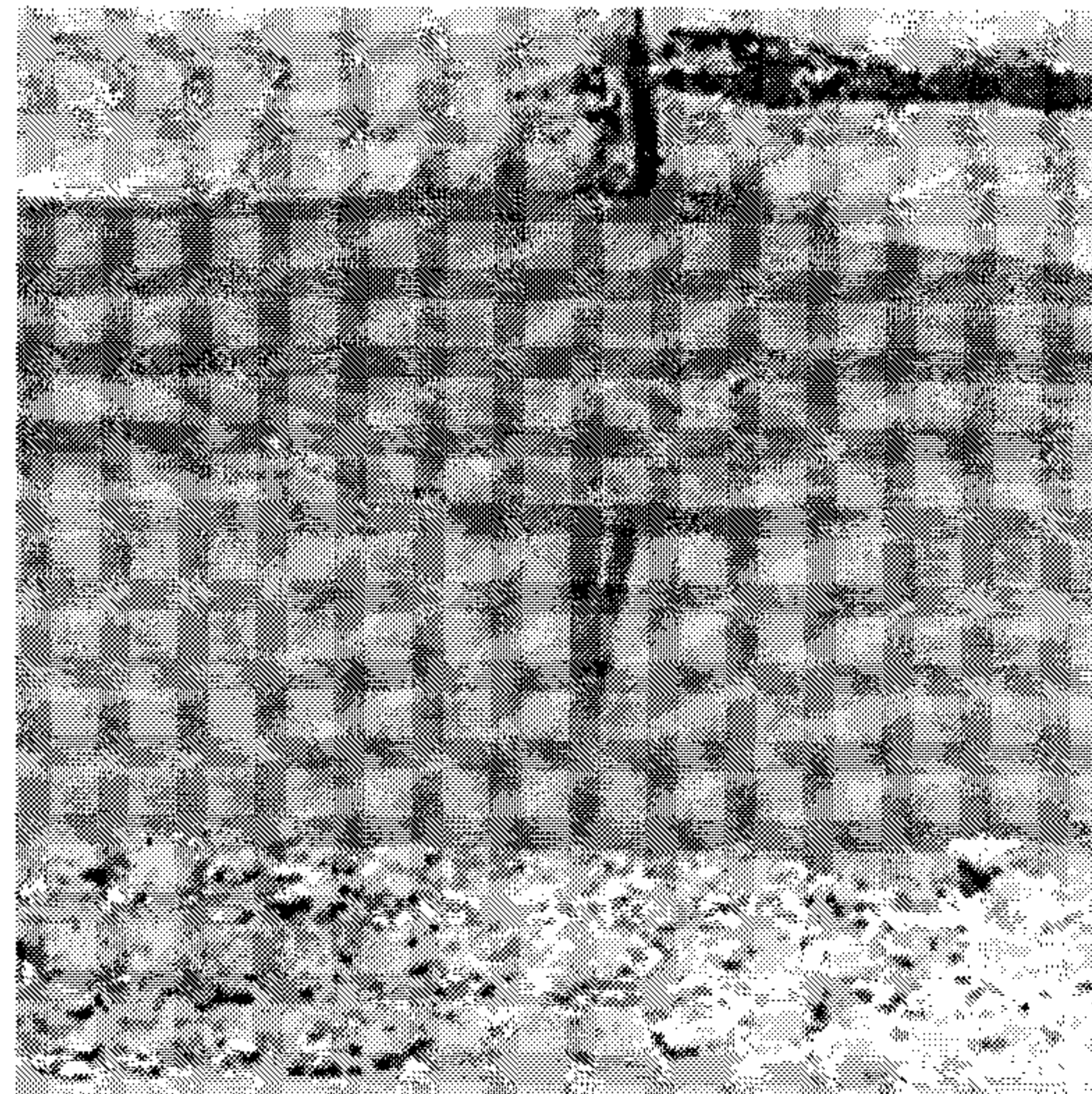


Figure 6: Treated @ 100gpt (Product 2B)

Figure 5 and Figure 6 show the discharge of the mineral sands tailings without and with treatment. In Figure 5, the tails are highly mobile and there is no deposition of solids at the point of discharge. Figure 6 shows stacking of the treated tailings underneath the discharge point and the liberation of clean water in the foreground.

EXAMPLE 13

Product 2B is an inverse emulsion containing a 30/70 sodium acrylate/acrylamide copolymer as used in Example 12 above. Product 3 is a solution grade, sodium polyacrylate homopolymer.

Product 2B was inverted into water to provide an aqueous solution containing 1.0% product as supplied. Product 3 was used as supplied with no further dilution necessary. The polymers were evaluated on a combined fine and coarse tailings from a mineral sands operation. The solids of the combined tails was 67% wt/wt with a fines/coarse ratio of approximately 1:7.

Laboratory Evaluation

Treatment tests, employing the solution of Product 2B, and Product, 3 were conducted using the following method:

1. A 250 ml aliquot of the homogenous combined tails slurry is placed into a 500 ml beaker.
2. The slurry is then subjected to mixing of ~500rpm using an overhead stirrer and a suitably machined paddle impellor.
- 5 3. The required dose of polymer is added to the slurry and mixing continued for either 10, 20 or 30 seconds.
4. Approximately 150 ml of the treated slurry is transferred to a 200 ml beaker and the yield stress measured using a vane viscometer.

Further tests were also carried out on Product 2B and 3 to evaluate the effect of different fines/coarse tailings ratio, using the above procedure and a constant mixing time of 20 seconds.

Results

Table 20

Product	Dose (g/t)	Yield Stress (Pa) After Mixing		
		10 sec	20 sec	30 sec
Blank	0	65	64	63
Product 2B	53	109	103	90
	107	217	183	115
	160	356	290	211
Product 3	622	97	105	95
	888	181	200	168
	1155	278	351	273

- 15 The results show that both products increased the yield stress of the combined mineral sands tails. Free water drainage was present at high doses.

The effect of different fines to coarse ratios are represented graphically below. At all ratios tested, both Product 2B and Product 3 significant
 20 increased the yield stress of the mineral sands tailings.

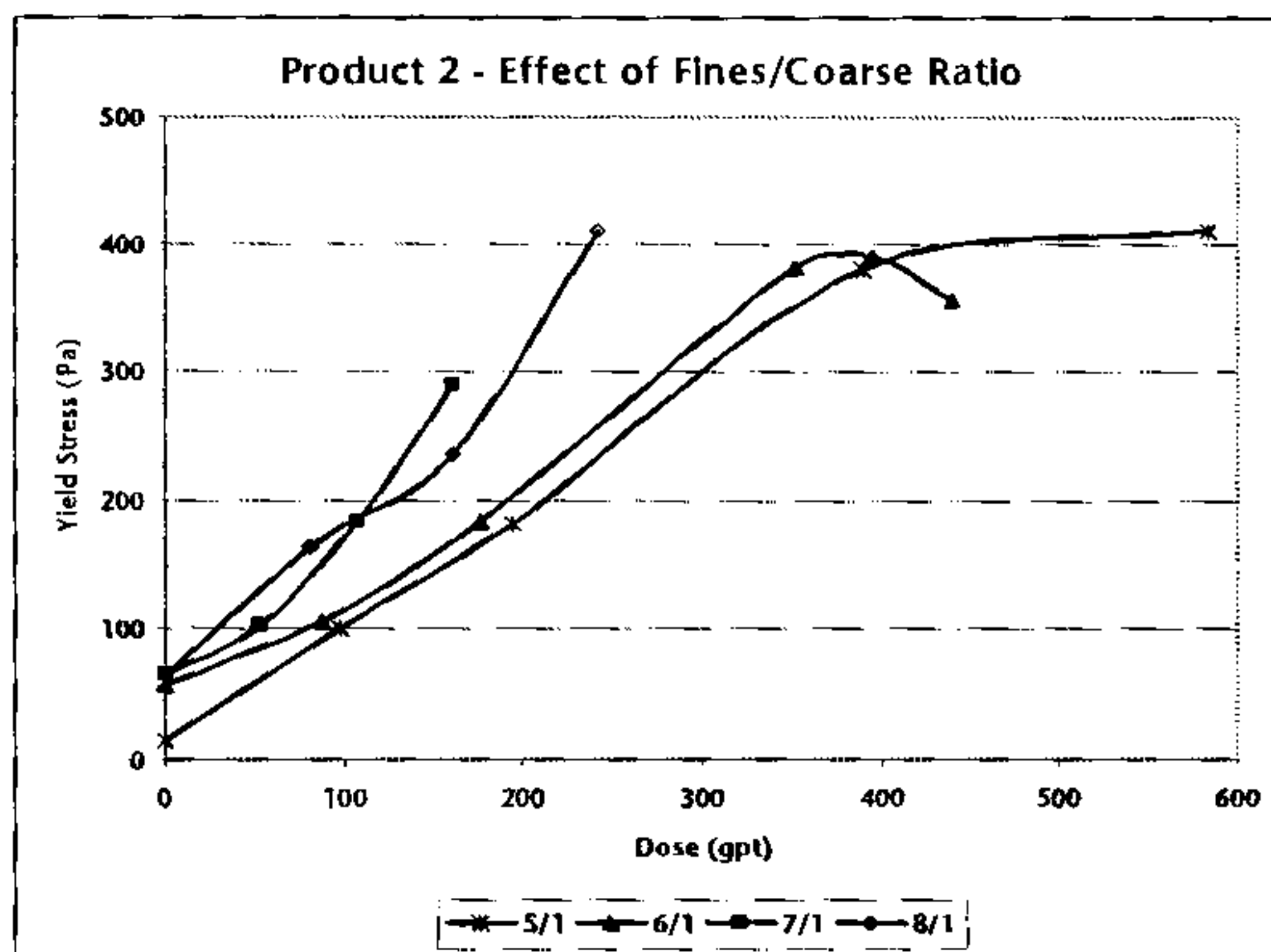


Figure 7:

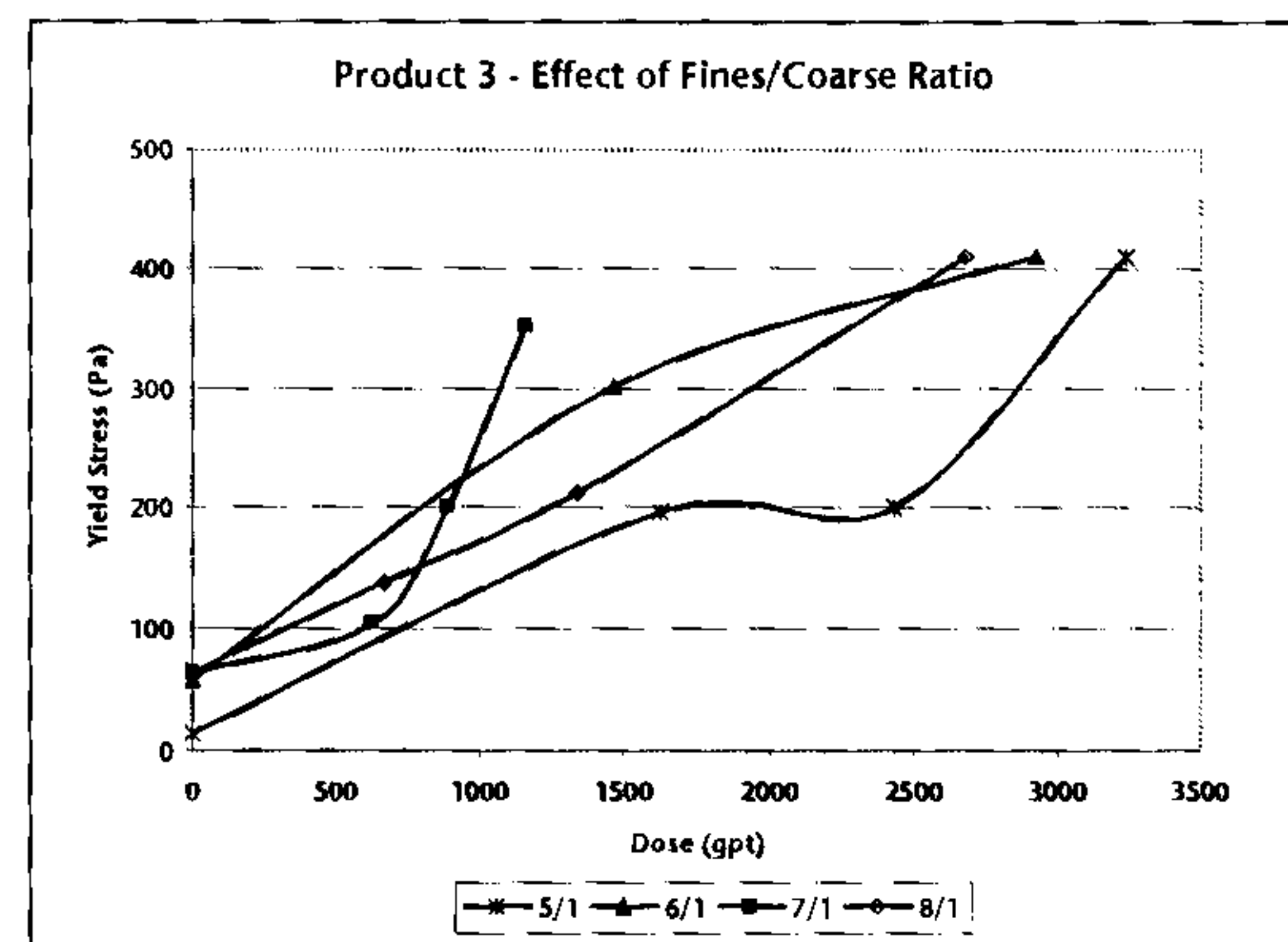


Figure 8:

Plant Evaluation

The underflow of a thickener in which slimes are compacted is combined with the waste sand fraction from the Mineral Sands operation. The ratio of sand to slimes varies with ore type, and the rheology and drainage rates of the deposited combination vary as a result.

The mining operation is mobile and follows the line of the ore body. The combined waste material is pumped to a series of pits that are filled sequentially and re-vegetated afterwards. It is desirable for the mining company to operate in as small a footprint as possible at any one time. Faster dewatering rates would allow the rehabilitation process to be started earlier. Additional drainage water could be returned to the process plant for improved efficiency's and reduced imported water costs.

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The application of this invention at the site described above is as follows:

Product 3 was dosed at dosage was 1050 gpt over a three day period, added after the screw conveyer and before the small centrifugal pump. The result was an improved slump angle and much greater release of water from the slurry. Figures 9, 10 and 11 show the slump angle at discharge into the dam for untreated tails, and tails treated with 513 gpt and 1050 gpt respectively.

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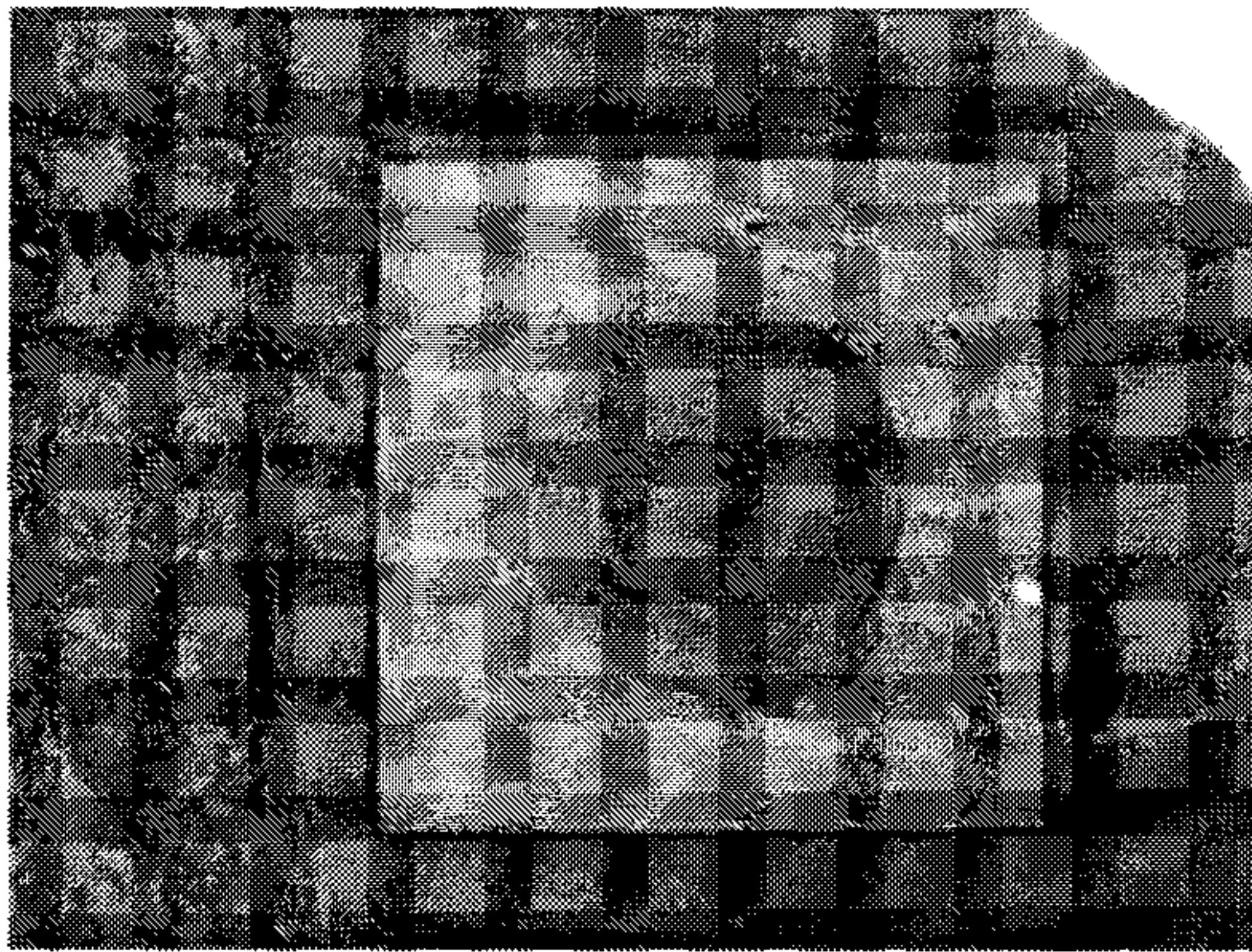


Figure 9: Untreated

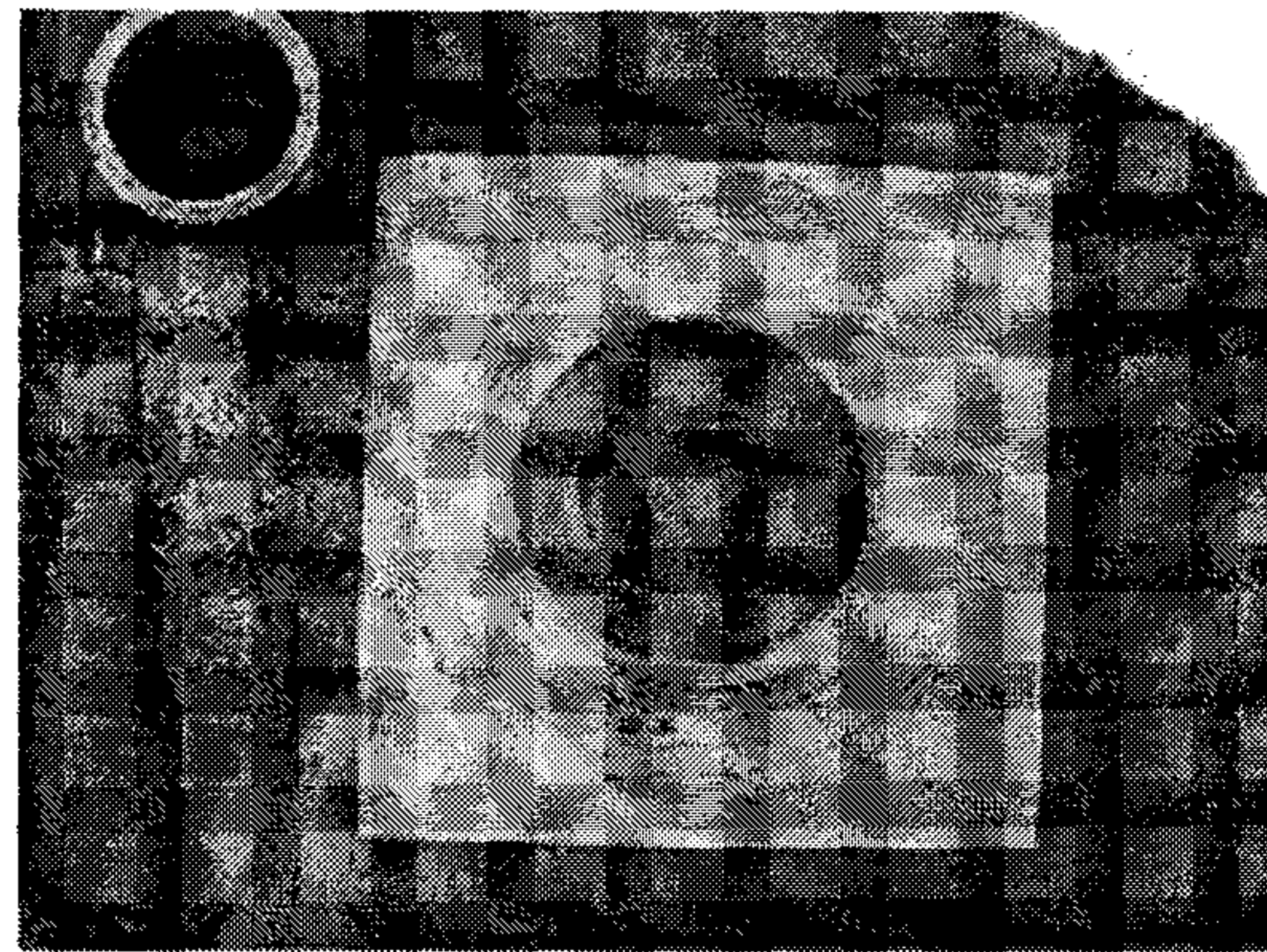


Figure 10: Product 3 @ 513gpt

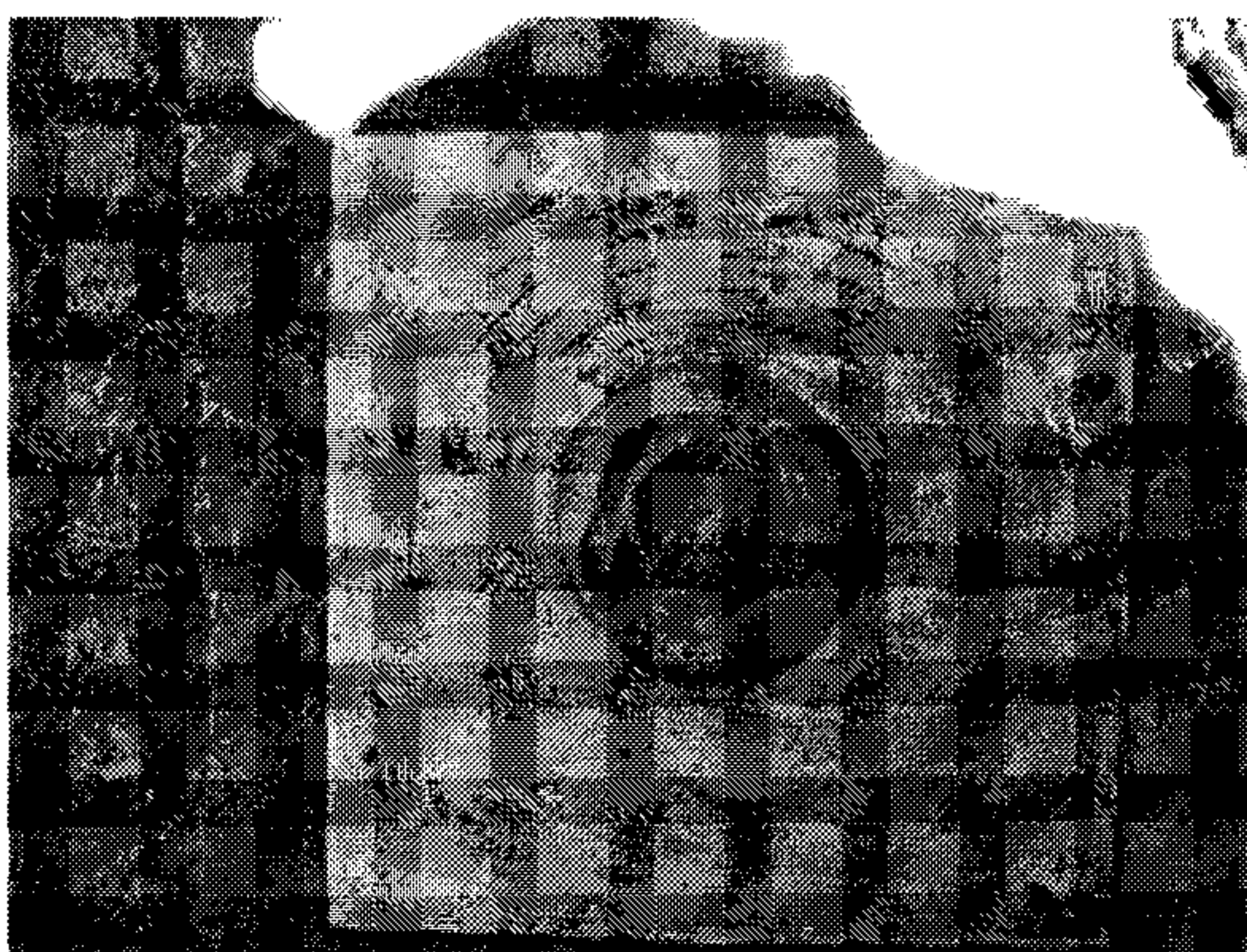


Figure 11: Product 3 @ 1050gpt

The dosing point was modified and Product 3 added directly after the centrifugal pump. The dosage was reduced to 726g/T with the alternative position. The same sand consistency was generated using this point.

- 5 24hours later the free drainage and porosity on the surface of the dam was apparent. Figures 12 and 13 show the discharge characteristics and the dam surface respectively.

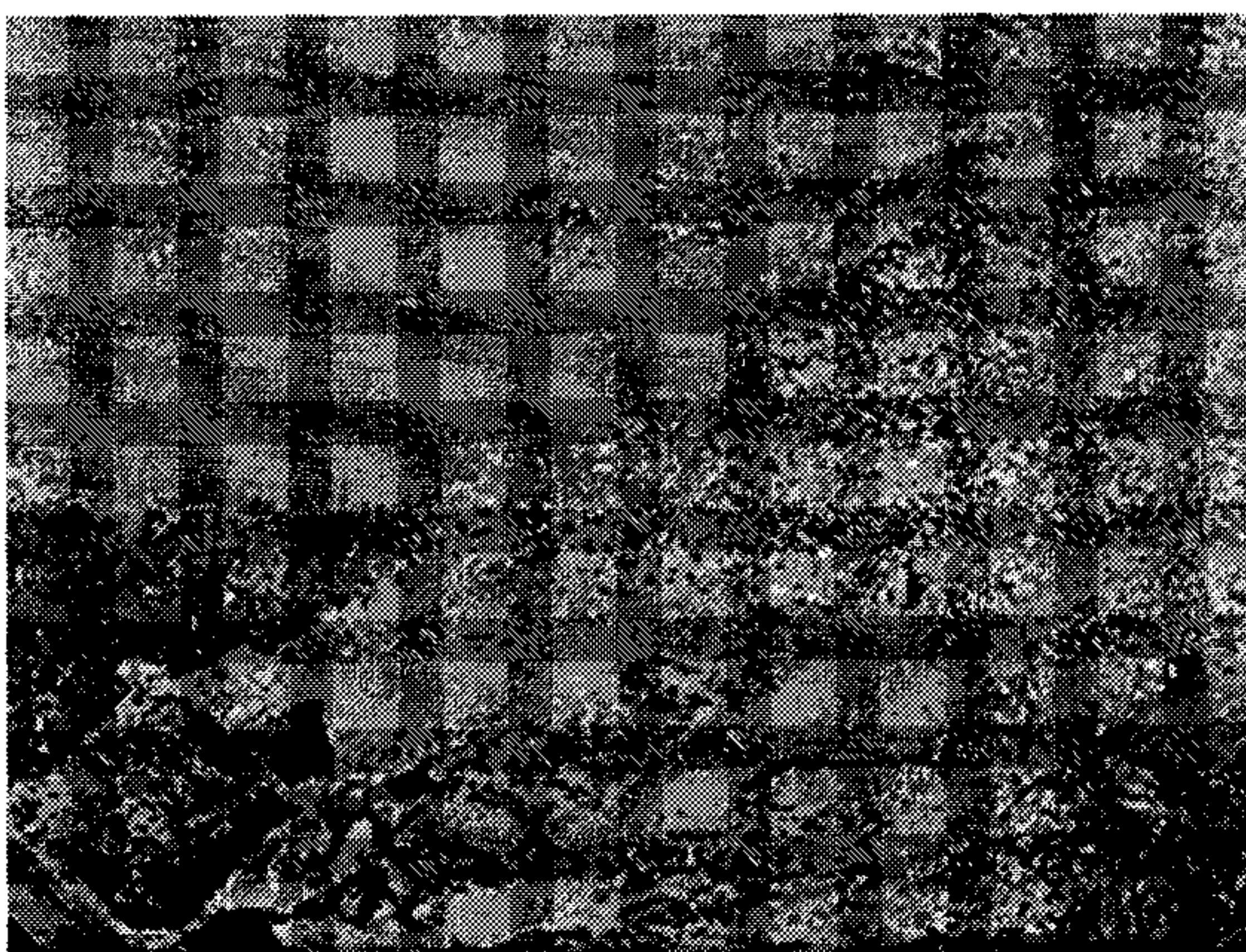


Figure 12: Discharge Pipe

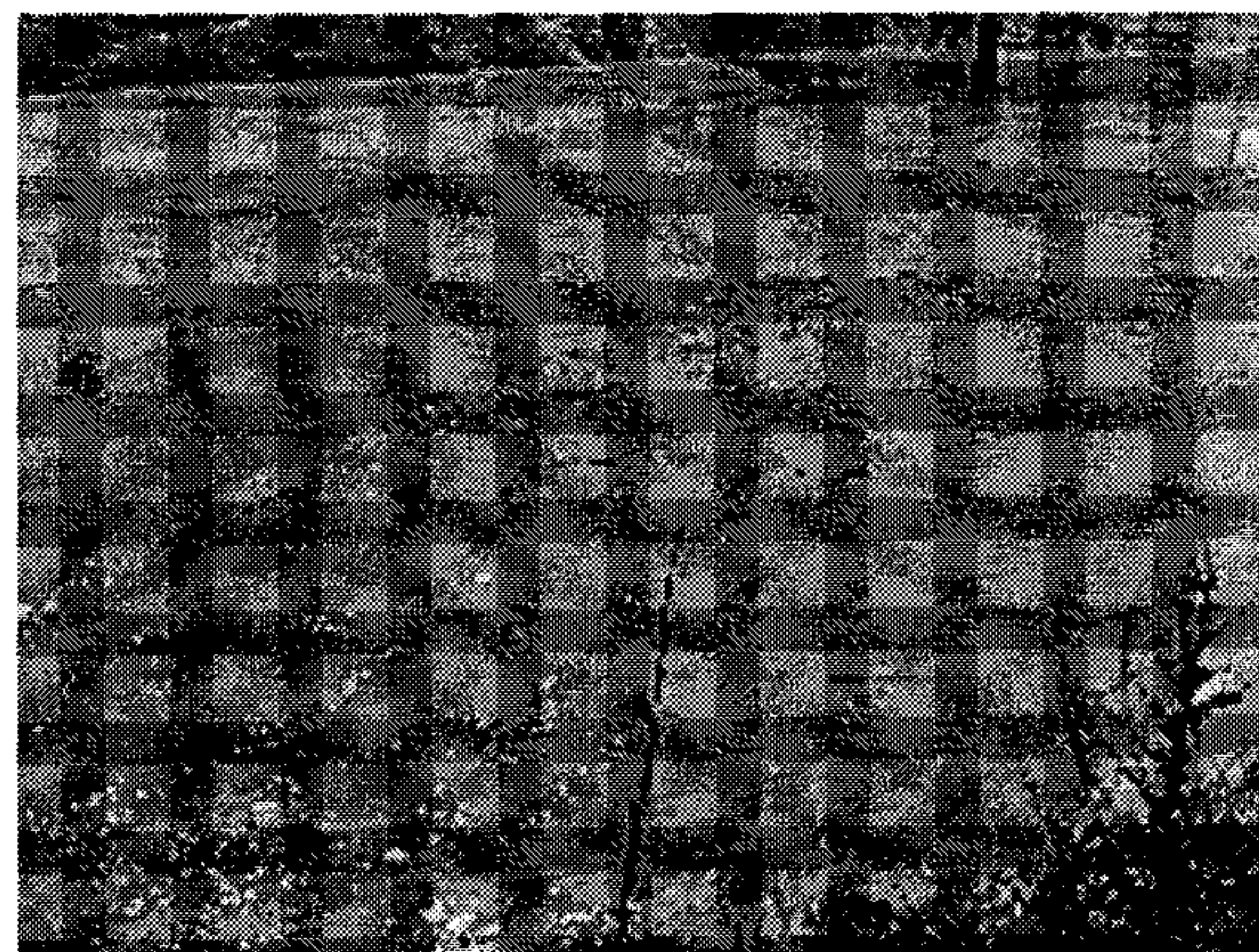


Figure 13: Surface Area

EXAMPLE 14

Selected samples taken from example 1 were evaluated according to the procedures detailed in example 1 using a tailings slurry obtained from a oil sands processing operation. Facility was included for the collection and measurement of the quantity and residual suspended solids content of the released water. Due to the poor turbidity of the release water, a water clarifier was added to the tailing treatment process. Clarity was assessed by percentage solids (water can be accepted straight into the plant if the water solids are below 0.5%).

Tests were conducted using a 70mm by 70mm collar. Rheology modifier products were prepared and used at a concentration of 0.3% and the water clarifier was prepared and used at a concentration of 1%. Clarifier solution is added several seconds after the rigidifying polymer is added.

Water quantity and quality were evaluated after 30 minutes. All test work was conducted at 40 °C.

20 Table 20

Solids Content (% wt/wt)	51.8
Sand to fines ratio	6.05:1
Specific Gravity	1.45

Results

Table 21

Sample	Dose (gpt)	d (mm)	c (mm)	e (mm)	Slump (%)	Released Water	
						Available water release (%)	Suspended solids (%)

Blank	0	>200	-	-	0	-	-
D	155	160	20	4	20.0	25.1	-
	130	180	22	4	20.0	44.7	1.12
	104	121	14	3	18.2	55.7	1.39
D + water clarifier	130 + 45 clarifier ¹	150	29	5	32.0	36.9	0.29
	104 + 45 clarifier ¹	90	45	0	100.0	47.9	0.25
	78+ 43 clarifier ¹	140	50	0	90.9	52.5	0.35
	104+ 21.5 clarifier ¹	120	40	0	66.7	52.0	0.59
D + water clarifier	104+ 43 clarifier ²	180	42	0	46.7	47.3	0.93
	104+ 86 clarifier ²	110	40	0	72.7	63.1	0.26

1. Low molecular weight anionic polymer.

2. Low molecular weight cationic polymer.

The results shows that stacking can be achieved when using Product D. However results indicate that the water release when using Rheology
5 modifier D alone is improved when a water clarifier is employed in combination with a Rheology modifier. The water released is of suitable quality for re-use in the plant without the need for further water polishing.

Claims

1. A process in which material comprising an aqueous liquid with dispersed particulate solids is transferred as a fluid to a deposition area, then
5 allowed to stand and rigidify, and in which rigidification is improved whilst retaining the fluidity of the material during transfer, by combining with the material an effective rigidifying amount of an aqueous solution of a water-soluble polymer and,
wherein the dispersed particulate solids are in all or in part oil sands tailings.
- 10 2. A process according to claim 1 in which the water soluble polymer has an intrinsic viscosity of at least 3 dl/g and is formed from ethylenically unsaturated water-soluble monomer or blend of monomers.
3. A process according to claim 1 or claim 2 in which the water soluble polymer is anionic.
- 15 4. A process according to claim 3 in which the polymer is formed from monomer(s) selected from the group consisting of (meth)acrylic acid, allyl sulphonic acid and 2-acrylamido-2-methyl propane sulphonic acid as the free acids or salts thereof, optionally in combination with non-ionic co-monomers, selected from the group consisting of (meth)acrylamide, hydroxy alkyl esters
20 of (meth)acrylic acid and N-vinyl pyrrolidone.
5. A process according to claim 1 or claim 2 in which the water soluble polymer is non-ionic.
6. A process according to claim 5 in which the polymer is formed from monomer(s) selected from the group consisting of (meth) acrylamide,
25 hydroxy alkyl esters of (meth) acrylic acid and N-vinyl pyrrolidone.
7. A process according to claim 1 or claim 2 in which the water soluble polymer is cationic.
8. A process according to claim 7 in which the polymer is formed from monomer(s) selected from the group consisting of dimethyl amino ethyl
30 (meth) acrylate - methyl chloride, (DMAEA.MeCl) quat, diallyl dimethyl ammonium chloride (DADMAC), trimethyl amino propyl (meth) acrylamide

chloride (ATPAC) optionally in combination with non-ionic co-monomers, selected from the group consisting of (meth) acrylamide, hydroxy alkyl esters of (meth) acrylic acid and N-vinyl pyrrolidone.

9. A process according to any of claims 1 to 8 in which the process
5 comprises the disposal of oil sands tailings from an oil sands processing operation.

10. A process according to any of claims 1 to 9 in which the dispersed particulate solids have particle sizes less than 100 microns, in which preferably at least 80% of the particles have sizes less than 25 microns.

10 11. A process according to any of the claims 1 to 11 in which the dispersed particulate solids has a bimodal distribution of particle sizes comprising a fine fraction and a coarse fraction, in which the fine fraction peak is substantially less than 25 microns and the coarse fraction peak is substantially greater than 75 microns.

15 12. A process according to any of claims 1 to 11 in which the material has a solids content in the range 15% to 80% by weight, preferably in the range 40% or 50% to 70% by weight.

13. A process according to any of claims 1 to 12 comprising flocculating an aqueous suspension of solids in a vessel to form a supernatant layer
20 comprising an aqueous liquor and an underflow layer comprising thickened solids forming the material, separating the supernatant layer from the underflow, wherein the underflow containing the particulate material flows from the vessel and, in which the material is then pumped to a deposition area where it is allowed to stand and rigidify, and wherein the effective
25 rigidifying amount of the aqueous solution of the water-soluble polymer is mixed with the material after flocculating the suspension and before the material is allowed to stand.

14. A process according to claim 13 in which wet or dry coarse particles are added to the underflow from the vessel either before or during the
30 addition of an effective rigidifying amount of the water soluble polymer.

15. A process according to claims 13 or 14 in which the material is transferred to a holding vessel prior to being pumped to the deposition area.

16. A process according to any of claims 1 to 15 in which the material is pumped to an outlet, where it is allowed to flow over the surface of previously rigidified material, wherein the material is allowed to stand and rigidify to form a stack.
- 5 17. A process according to any of claims 1 to 16 in which the effective rigidifying amount of the aqueous solution of the water-soluble polymer is mixed with the material prior to a pumping stage.
18. A process according to any of claims 1 to 16 in which the effective rigidifying amount of the aqueous solution of the water-soluble polymer is
10 mixed with the material during or subsequent to a pumping stage.
19. A process according to any claims 1 to 16 in which the effective rigidifying amount of the aqueous solution of the water-soluble polymer is mixed with the material as it exits the outlet.
20. A process according to any of claims 1 to 19 in which the material is
15 dewatered during rigidification, releasing liquor.
21. A process according to claim 20 in which the liquor is recycled to a oil sands processing operation.
22. A process according to claim 20 or claim 21 in which the clarity of the liquor is improved by the addition of an aqueous solution of water-soluble
20 polymer.
23. A process in which material comprising an aqueous liquid with dispersed particulate solids is transferred as a fluid to a settling area, then allowed to dewater to release liquor, and in which dewatering is improved whilst retaining the fluidity of the material during transfer, by combining with
25 the material an effective dewatering amount of aqueous solution of a water-soluble polymer
- and wherein the dispersed particles are in all or in part oil sands tailings.
24. A process according to claim 23 comprising flocculating an aqueous suspension of solids in a vessel to form a supernatant layer comprising an
30 aqueous liquor and an underflow layer comprising thickened solids forming the material, separating the supernatant layer from the underflow, wherein

the underflow containing the material flows from the vessel and in which the material is then pumped to a settling area where it is allowed to dewater, and wherein the effective dewatering amount of the aqueous solution of the water-soluble polymer is mixed with the material after flocculating the suspension and before the material is allowed to dewater.

25. A process according to claims 23 or 24 in which wet or dry coarse particles are added to the underflow from the vessel either before or during the addition of an effective dewatering amount of the water soluble polymer.

26. A process according to any claims 23 to 25 in which the liquor is recycled to an oil sands processing operation.

27. A process according to any claims 23 to 26 in which the clarity of the liquor is improved by the addition of aqueous solution of water-soluble polymer.

28. A process according to any claims 23 to 27 in which the liquor contains dissolved valuable materials and in which the liquor is subjected to further processing to reclaim or reuse the valuable materials.

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