

## Changing your Disposal Model: Utilization of E & P-Generated Recycled Solids

By Richard L. Wynn, CEO, Deep River Group, Geologist

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### Abstract

E&P-generated waste streams can be economically recycled into high-quality structural base material suitable for constructing the multiple-borehole drilling pads, lease roads, production facilities, mid-stream facilities and county roads used extensively within E&P unconventional harvesting trends. Recycling E&P waste streams provides substantial cost savings in transportation, waste management, site construction, and liability management. Recycling can also provide LEED or "green" credits. Innovative use of geothermal technologies to clean cuttings and drilling muds as part of the recycling process within the Eagle Ford Shale trend can provide additional cost and environmental benefits.

### Introduction: History of Recycling Oilfield Waste in the State of Texas

A methodology for converting oil and gas solid waste streams into a specified recycled material using a defined and permitted manufacturing process was invented in 1997.<sup>1</sup> These efforts led to the first recycling permit issued within the state of Texas in 2002 and to the promulgation of Texas Administrative Code, TITLE 16 (Economic Regulation), PART 1 (Railroad Commission of Texas), CHAPTER 4 (Environmental Protection), SUBCHAPTER B (Commercial Recycling) in December 2006.<sup>2</sup>

These efforts established the compliance requirements of the recycling process. This included meeting standards and specifications set by the Texas Department of Transportation (TxDOT) for use of cold mix recycled materials,<sup>3 4</sup> material handling procedures for sampling, laboratory analysis, engineering testing, and waste tracking under procedures monitored by the Texas Railroad Commission, and confirming compliance with EPA regulations under the Code of Federal Regulations.<sup>5</sup>

The first permitted recycling facilities were limited in scale and principally supported local county commissioners attempting to create county roads using lower cost road base material. A limited number of E&P operators utilized the locally sourced recycled material for drilling pad construction. This use was limited by cost restraints associated with transportation and distance to material sources.

The majority of E&P waste recycling benefits occur when there is close proximity to the processing facilities and with

proper management of transportation logistics. An example would be reducing "deadhead loads" where a truck returns empty. With a fully integrated recycling facility, the ability to receive waste streams and reload the same vehicle with road base material (after proper cleaning) greatly reduces transportation costs and locates construction materials in local staging areas ready to deploy within the next pad, lease road or other support facility.

### Transforming waste into high-grade building material

The ability to custom blend drilling solid waste streams, aggregates, cement and other filler materials greatly enhances the load bearing ability of recycled materials. Compressive strength is a measurement of the capacity of a material or structure to withstand loads. Higher compressive strength greatly reduces the amount of material required.

Traditional models to remotely "recycle" drilling waste from solids are limited to dilution with locally-sourced soil with limited compressive strengths in a modified form of land farming. These materials allow for local disposal as a sub-base for lease roads but generally do not qualify for the heavy load bearing requirements of drilling pads, production facilities and other critical foundation support structures. This traditional approach reduced disposal expenses by reducing transportation costs, but still left the waste generator with contingent liability for drilling waste streams.

### Severing Contingent Liability for Oilfield Waste

The ability to truly change the waste stream into a manufactured product that meets government-defined specifications achieves two major benefits: (1) by creating a structurally superior material which satisfies the structural load bearing requirements of harvest drilling techniques, the operator reduces both construction and waste disposal costs, and (2) by transforming the waste stream into a manufactured, salable product, the operator severs the contingent liability of the waste stream, removing the operator's cradle-to-grave environmental concerns for their waste streams. This can result in additional cost savings with respect to liability insurance.

## Changing the model to match the new reality

What's changed? Unconventional shale drilling successes have radically changed the drilling landscape. Whereas traditional discovered resources were generally limited in size and scope, unconventional shale discoveries have created massive contiguous resource fields which require extensive boreholes to exploit. The industry is rapidly transitioning to multi-borehole pad drilling for asset development.

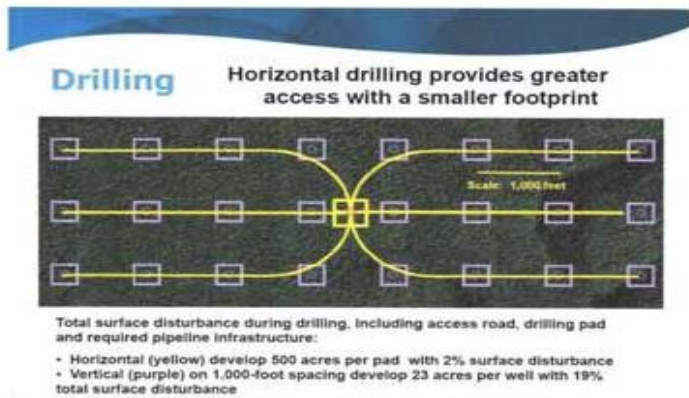


Fig 1: Range Resources Vertical to Horizontal layout<sup>6</sup>

These multi-borehole pads are larger, used longer, include walking or skidding rigs, and support multiple concurrent operations (drilling, completion, and re-works), all of which require higher structural load-bearing integrity for pad sustainability. With multi-borehole pads, the strong-back for walking or skidding rigs and the apron area around the pad and strong-back is highly critical to operational safety, logistics, and the success of close-density drill spacing. A properly manufactured recycled road base material can provide the requisite structural load bearing capacity far more economically than traditional construction materials.

Recycled road base can also be used for construction, improvement and repair of lease roads, production facilities, mid-stream facilities, and country roads used extensively within E&P unconventional harvesting trends.

Emerging development trends are creating production corridors which concentrate production and development operations within highly defined areas. These corridors require extensive expansion or improvements to existing local infrastructure to provide safe and environmentally-sound access to developing resource trends. The inherent problems of concentrated use require higher structural integrity for lease roads, county roads, turn-around, and major public highway passing lanes.

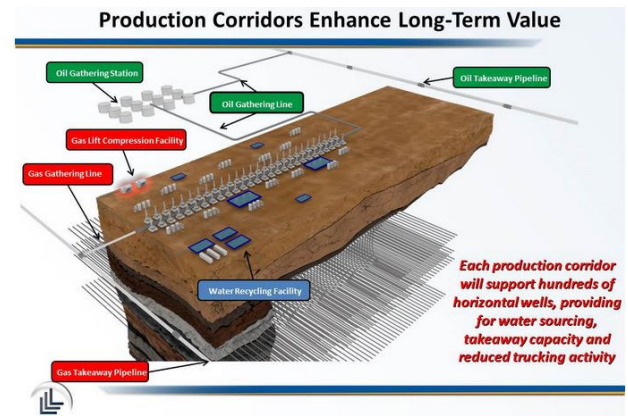


Figure 2: Multi-borehole production corridor configuration, Laredo Petroleum<sup>7</sup>

## Developing all drilling operation resources

Drilling waste streams have historically been delegated to disposal and its associated material handling expenses, due to limited or nonexistent recycling options. It is now possible to integrate close-proximity recycling facilities with the emerging development trends of multi-borehole pads and activity concentration, and thereby provide substantial cost savings.

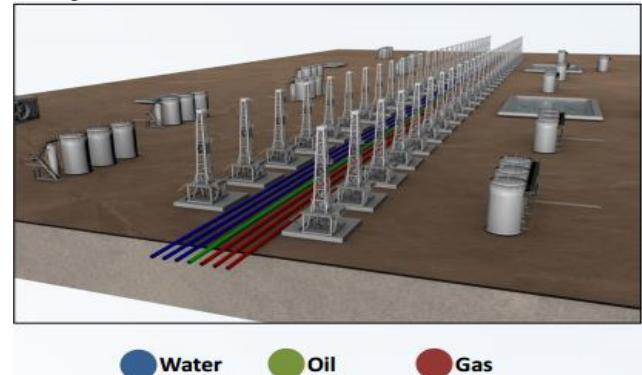


Fig 3: Multi-borehole pads and concentrated activity<sup>8</sup>

The drilling solids and micro-fine solids transferred into drilling muds, which are traditionally disposed as waste, can become the backbone for superior structural load-bearing material. This resource, once properly recycled, dramatically reduces construction material and replacement drilling fluid requirements. When coupled with logistics management between drilling and infrastructure construction cycles, marked cost savings can be realized.

An excellent example of utilizing a recycled product and the associated cost savings was achieved by a major public E&P company with operations in the Eagle Ford Shale trend. Their operation model changed to disposal of all drilling operation solids and spent oil base mud at a local recycling facility. Upon review and testing of the viability of recycled materials generated at the facility, tests were conducted to confirm material specifications, application procedures, logistics of elimination of transportation deadhead loads, cost reductions, and long-term stability. An additional

consideration was the inherent value of responsible environmental stewardship, public safety with reduction of truck traffic, and reduction of disposal liability.

The company was able to capture cost savings in excess of \$50 thousand per drill pad and \$15 thousand per borehole on replacement oil-based mud. As the company increased development activity and optimized drilling operations, over 80 locations were built with savings exceeding \$6 million. The basic multi-borehole pad utilized required 6,500 Y<sup>3</sup>, comprised of 8 inches of recycled base material compacted to 6 inches and 4 inches of standard limestone aggregate compacted to 2.5 / 3 inches as a wear surface. The recycled base material displaced all the traditionally required sub-grade, sub-base and sub-road base materials.

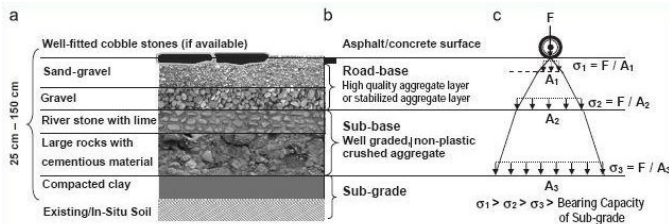


Fig 3. (a) Basic Roman road design,  
(b) 2000 road design,  
(c) model of force distribution<sup>9</sup>

Local supporting lease and county roads were constructed with the same volumetric design, with county roads to be finished with an asphaltic chip top seal after major drilling activity diminished in the area. Local county road construction costs were reduced by more than 35 percent compared to standard application methods. An added realized benefit was the inherent stabilizing characteristic of the base material in soft (sandy) or low wet areas. The cement additives used in the manufacturing process greatly reduced the requirement for large aggregate (bull rock) and other materials normally used in such circumstances.<sup>10</sup>

### Understanding your resource potential

The average horizontal 15,000' measured depth borehole generates in excess of 450 Y<sup>3</sup> of drill solids and upwards of 200 barrels of spent oil-based mud due to excessive micro-fine solids and water. The standard multi-borehole pad utilizes 3 or more boreholes per pad.

Using a standard four borehole per pad configuration, an average of 1,800 Y<sup>3</sup> of solid material and 800 barrels of spent oil base mud is generated. Existing recycling process methods create a superior load-bearing material that converts the 1,800 Y<sup>3</sup> into approximately 3,600 Y<sup>3</sup> of manufactured base. The average four borehole drilling pad dimension is 400' by 500', or approximately 200,000 ft<sup>2</sup>, dependent on terrain limitations or future expansion designs.

The average total material construction volume without excessive slope requirements is generally 5,000 Y<sup>3</sup> or more. Thus, recycled base material can contribute approximately 60% of the required fill material (3,600/5,000 =60%).

With an ongoing corridor-type development program or

close regional proximity program, an operator could readily generate sufficient construction material volume from one drilling pad for construction of the next pad. This would markedly reduce transportation costs from distant quarry locations, promote public safety, potentially eliminate the transportation of all waste streams to traditional disposal facilities, and sever contingent liability obligations. In addition, all solids extracted by the drilling mud recycling operations are converted into the same base material. Reclaimed drilling muds can be reused as a blend stock in ongoing operations.

Excess material volumes can be absorbed by pad expansion, other support facilities, or local state/county road expansion and construction projects.

### Green credit and LEED compliance

The recycling process can generate LEED or "green" credits. Alternatively, operators can realize tax credits through donation of road base material to governmental or qualifying entities.

Environmental stewardship necessitates innovation and as such requires change from traditional E&P practices. Society rewards such corporate stewardship with favorable opinion and support.

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods. Developed by the U.S. Green Building Council (USGBC), LEED helps building owners and operators be more environmentally responsible and use resources efficiently.

Under LEED 2009, there are 100 possible base points distributed across six credit categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation in Design. Recycled materials constitute the majority of base scoring within the category "Materials and Resources."<sup>11</sup>

Industrial Materials Recycling and LEED® Credits	Points
Using construction and building products containing recycled content	1-2
Reusing building materials and products	1-2
Diverting C&D materials from disposal	1-2
Using materials extracted, processed, and manufactured locally	1-2
Total Possible Points	8

Fig 4. EPA Construction Initiative<sup>12</sup>

Buildings can qualify for four levels of certification:

- Certified: 40–49 points
- Silver: 50–59 points
- Gold: 60–79 points
- Platinum: 80 points and above

This conservative scoring of 8 points is fully 20 percent of required total points for certified status. Additional points could be scored within the Sustainable Sites, Water



Efficiency, Energy and Atmosphere, and Innovation in Design categories.

The LEED model demonstrates a pathway the E&P industry could follow to improve its operational model. As an industry, we need to better demonstrate and communicate our environmental leadership. The LEED program demonstrates a method to score building construction and sustainability. The same model could also be used to score the construction of load-bearing structures (drilling pads, lease roads, production facilities, drilling fluids, and even casing cement designs) used extensively in E&P resource development.

Donation of materials is an approved method to assist local communities with infrastructure capital expenditures. The local county and state roadways have limited resources to deal with the extensive roadway demand the E&P industry requires to develop asset resources. Laws are in place to provide tax credits for donated “like kind” materials or funding to assist local county needs. These credits are priced at prevailing market conditions for material donated. The ability to convert E&P waste streams into marketable resources changes the dynamic relationship between operators and their local community.

The “greening” of the E&P industry practices benefits the environment, enhances public safety, and can materially improve your financial bottom line.

### Cleaning oilfield waste with geothermal technology

Innovative use of geothermal technologies to clean cuttings and drilling muds for recycled use within the Eagle Ford Shale trend is achieved by coupling a local renewable resource with the recycling manufacturing process. The south central Texas gulf coast is known for the potential recovery and use of geothermal energy. A leading E&P waste recycling group is changing the renewable landscape by siting a processing facility within a known geothermal geo-pressured area of the Eagle Ford Shale trend. The siting is adjacent to the only geothermal energy recovery project utilizing existing deep geo-pressured boreholes within the state of Texas.

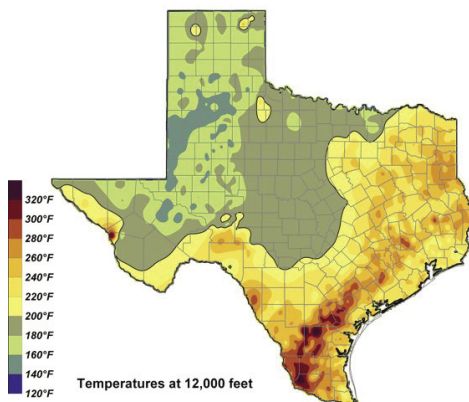


Fig 5: Geothermal resources Texas<sup>13</sup>

This renewable energy plant will supply 100 percent of electrical supply and hot water required to enhance process

drill waste streams. This closed loop system will recover hydrocarbons, remove chlorides from solids, create a concentrated 10 pound brine and generate fresh water supplies for internal process fluids. This processing step greatly reduces the material handling issues associated with oil-laden solid and liquid streams and their closely linked salt and other contaminants. The quality manufactured product streams from this process include structural base material, micro-fine cement filler material and recycled building blocks.

The location of this site is adjacent to the prolific Karnes trough of the Eagle Ford Shale trend. The transportation distance for E&P generated waste streams is fully one half or less the distance current operators are transporting waste streams for traditional disposal.

### Conclusion

The ability to process drilling-generated waste streams and convert them into a reusable resource changes the dynamics for E&P operators. The E&P industry can change their disposal models by recycling, re-tasking, and reusing their generated waste streams. In sum, innovative recycling transforms waste into wealth.

### Acknowledgments

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### Nomenclature

Define symbols used in the text here unless they are explained in the body of the text. Use units where appropriate.

$(ft^3)$	=	<i>cubic feet</i>
$(Y^3)$	=	<i>cubic yards</i>
$(OBM)$	=	<i>oil based mud</i>
$(MD)$	=	<i>measured depth</i>

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