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INNOVATIVE USES OF RECYCLED TANK TRACKS FOR EROSION CONTROL

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INNOVATIVE USES OF RECYCLED TANK TRACKS FOR EROSION CONTROL

1. Purpose. The purpose of this Public Works Technical Bulletin (PWTB) is to transmit current information on the reuse of recycled materials for erosion control projects, cost-effectiveness, and proper installation of projects.

2. Applicability. This PWTB applies to all U.S. Army installations.

3. References.

a. PWTB 420-49-12, Army Recycling Lessons Learned, 22 May 2001.

b. Army Regulation (AR) 420-49, Utility Services, 28 April 1997.

4. Discussion.

a. PWTB 420-49-12 summarizes lessons learned in establishing successful recycling programs on Army installations.

b. AR 420-49 contains policy and criteria for the reoperation, maintenance, repair, and construction of facilities and systems, for efficient and economical solid (nonhazardous) waste management including source reduction, re-use, recycling, composting, collection, transport, storage, and treatment of solid waste.

c. Installations generate large volumes of solid waste from maintenance of training vehicles. Many of the materials that cannot be sold as scrap metal through the Defense Reutilization and Marketing Office (DRMO) program, eventually are landfilled. Finding innovative re-uses for items such as tank tracks, steel cable, clamps, etc. will reduce the volume of waste, open up space in DRMO yards and may effect significant savings in the long-term.

d. Appendix A provides detailed information on costs and efficacy associated with the re-use of tank treads for erosion control structures, samples of designs, and (im)proper implementation of tank tracks.

e. Appendix B contains erosion data for the Fort Carson and Colorado Springs tank track implementations.

5. Points of Contact. HQUSACE is the proponent for this document. The POC at

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APPENDIX A

Recycling DRMO Materials for Erosion Control

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Background

a. Although recycling is not a 100 percent solution to diverting solid waste from landfills, it is an essential component of any installation's solid waste management program. Finding creative alternative reuses for materials on-post can serve many purposes such as:

- Reducing disposal costs for landfilling materials
- Reducing acquisition costs for raw materials
- Increasing availability of space in DRMO yards
- Potentially increasing long-term stability of rehabilitation projects.

b. This PWTB examines the various reuses of select DRMO materials (tank tracks and steel cable) for land rehabilitation projects. Some possible reuses include checkdams, streambank stabilization, hardened streamcrossings, amoring of culverts, and hardened helicopter pads. The idea to reuse tank tracks for streambank stabilization was an outgrowth of the cross-functional pollution prevention team at Fort Carson, Colorado. The installation generates up to 2 million pounds of unserviceable tank tracks each year. The tracks are temporarily stored at the DRMO yard until a buyer can be found or they are landfilled. Either selling or landfilling tracks may take years and can be problematic for the DRMO personnel who must find space to store these items.

c. Space in DRMO yards and landfills is a valuable commodity. At Fort Carson alone, the volume of unserviceable tank tracks will occupy a space equal to approximately 1,500 square feet in the DRMO yard. This may not seem significant on a yearly basis, but keep in mind this is only one item and it may take anywhere from 2 to 5 years to find a scrap metal buyer willing to purchase some of the unserviceable tracks. For many installations with mechanized training loads, tank tracks can quickly occupy a significant portion of available space.

Overview of Army Recycling Program

The Army is committed to improving recycling programs by considering novel approaches for reuse of materials on-site. Efforts are being made to conserve raw materials, find innovative reuses for products, and divert components from the solid waste stream. Being creative by employing the “recycling hierarchy” (reduce, reuse, recycle) can add up to large savings and good stewardship of resources.

Lessons Learned

Each Army installation has its own challenges to meet ranging from disposal of used materials and accounting for DRMO items, to mitigating erosion problems and implementing an effective project at a reasonable cost. The case studies presented in this PWTB address those issues and include the following:

- Evaluate the Return on Investment
- Coordinate with all stakeholders
- General guidelines
- Examples of successful implementations
- Summary

a. Evaluate the Return On Investment

i. When considering any type of military project, the costs involved must be weighed. In finding a creative reuse for tank tracks, we looked closely at the following associated costs:

(1) Using conventional erosion control products vs. reusing tank tracks.

In the Fort Carson demonstration project, we reused tank tracks in place of geoweb, concrete, or riprap. Overall, the project was labor intensive; dismantling and reassembling the tank tracks into useable lengths is very labor intensive. However, money was saved by not buying raw materials and by not paying for landfilling the tracks. Conservative national disposal costs for 1 ton of tank tracks (equivalent to 20 linear feet) is approximately $100. This disposal cost does not include transportation to and from the landfill.

For comparison, Table 1 lists costs in labor and material $/unit for the placement of gabions, riprap, sediment/silt fences, and tank tracks.

(2) Using a contractor vs. troop labor.

Many projects can be accomplished in several steps and are suitable for troop labor. However, if a project cannot be interrupted, as is the case with water crossings, consider using a contractor. When using either a contractor or troop labor, provide detailed schematics, instructions, and material needs along with an appropriate time line for the project.

(3) Longterm maintenance.

How much money is being spent to repair trouble spots? The City of Colorado Springs was installing gravel and/or asphalt twice annually at a road shoulder in the Pike's Peak

area along an asphalt road that was continually being eroded by runoff during storm events. The crew of four or five took a full 8-hour day for the work. By current (2002) costs, each maintenance action would cost about $2300. By using tank tracks to harden the site, no further maintenance has been needed since Spring 1998.

Table 1. Costs for material and labor associated with various erosion control methods.

Region	Estimate Type	Gabions (cy)*	Riprap (cy)*	Sediment Fence (lf)*	Tank Track Reuse (sq ft)**
Pacific Coast	Average	$86.35	41.07	.84	
	Range	75.44-95.12	35.88-45.24	.74-.93	
Intermountain	Average	78.87	37.51	.77	14.79
	Range	77-81.84	36.62-38.92	.75-.80	11 – 18.58***
Northern Great Plains	Average	76.74	36.50	.75	
	Range	71.42-79.46	33.97-37.79	.70-.78	
Southern Great Plains	Average	79.11	37.62	.77	
	Range	70.85-89.87	33.70-42.74	.69-.88	
Central Lake	Average	78.88	37.51	.77	
	Range	71.67-98.32	34.09-46.76	.70-.96	
Northeast	Average	81.16	38.60	.79	
	Range	71.83-107.99	34.16-51.36	.70-1.05	
Humid South	Average	75.36	35.84	.74	
	Range	65.60-97.74	31.20-46.49	.64-.95	

* cy = cubic yard; lf = linear foot. The numbers are labor and material $/unit for the placement of gabions, riprap, sediment/silt fences, and tank tracks.

** sq ft = square feet.

*** The numbers reflect tracks alone using contracted labor ($11) and tracks with geotextile, riprap, gravel, and cable using contract labor ($18.58). Note that the higher price reflects several structural problems encountered during construction, including stabilization of a sink hole.

(4) Environmental costs.

Many tracks have found their way to the coasts to serve as artificial reefs and shoreline stabilizers rather than having them occupy valuable landfill space. There are no regulations that explicitly limit this activity, and no known regulatory interest in reusing tracks in this manner. It is better to use tank tracks for these purposes than to have them occupying valuable landfill space. This approach may be the best disposal option for unserviceable tracks during overseas deployments. Raw materials are saved, the cost to transport used tracks back to the United States is saved, and hardened permanent sites are established.

ii. Not all costs/benefits are realized in the short-term. The Army can take a proactive role in adopting new reuses for materials and creating a vision for the long-term.

b. Coordinate with all stakeholders

i. First and foremost, coordinate with all of the personnel responsible for permitting processes on the installation. Reusing materials may be unfamiliar territory for some regulators, land managers, public works personnel, DRMO personnel, etc. Make sure everyone is on-board with implementing the new idea of reusing materials.

ii. It may be necessary to have laboratory personnel analyze some materials for potential residuals (like oil). For example, the tank tracks used in the Fort Carson projects were analyzed and cleared by installation laboratory personnel.

iii. Include all the expertise necessary to make the project a success. For example, soil scientists, environmental engineers, hydrologists, and biologists were consulted for the Fort Carson site.

iv. Talk to not only the DRMO personnel, but also to other departments or units on post. For example, the cable used in this project was salvaged from the DRMO, ITAM, and Engineer Units at Fort Carson. The largest contribution came from the Engineer Unit, which was changing out winching cables on its trucks. The cable may no longer be useful for hauling a humvee out of a boggy area, but it may be quite suitable for cabling together lengths of stationary tracks.

c. General Guidelines

i. To have a successful project, please keep the following in mind:

(1) Follow Best Management Practices (BMPs).

(2) Follow the permit process for any given project (e.g., 404).

(3) Enlist the help of specialists to include:
- (a) Engineers for design specifications and surveying, and
- (b) Hydrologists to determine watershed loads, streamflows, and geomorphology.
- (c) Other specialists that should be consulted might be Geotechnical Engineers, Environmental Specialists, and for larger drainage areas, Hydraulic Engineers.

(4) Have a solid design for any project implemented.

(5) Use caution when placing tracks.

(6) Incorporate tracks into the soil profile and under the water flow line so as to prevent undercutting and erosion in the future.

(7) Use geotextile between the soil and riprap/tracks to disperse the weight of the tracks evenly across the base of the project and reduce erosion.

(8) Interlock or cable the tracks together to make a single cohesive unit that does not easily move.

ii. To avoid pitfalls, respect the following guidelines:

(1) Do not place tracks directly on the soil surface, this leads to accelerated erosion (see Appendix B).

(2) Do not lay tracks against the contour.

(3) Do not lay tracks in such a fashion that they channelize water; stagger the placement.

d. Examples of Successful Implementations

i. The following are examples from several projects implemented at Fort Carson and Colorado Springs.

(1) Culverts: Armoring of inlet at City of Colorado Springs site. Figure 1 shows an unstable inlet that needed periodic maintenance to ensure the concrete was not being undercut by high intensity storm events.

Figure 1. Unstable culvert inlet.

Figure 2 is the same culvert after using tank tracks to harden the inlet. This project was concluded in 1998 and has not required any further maintenance.

Figure 2. Stabilized culvert inlet.

(2) Water Drainage Channel. For many years, the City of Colorado Springs had been spreading gravel and asphalt along a site on Old Stage Road above the historic Broadmoor Hotel. The road has a grade of approximately 8 percent at this site and is heavily inundated with runoff even during minor water events. At times, erosion has carved out a vertical dropoff of up to 3 feet. Although this is a secondary street, it is a major access for both the Broadmoor Stables and Gold Camp Road; it experiences heavy traffic loads.

a. The City first excavated the drainage channel to grade and laid geotextile down as the base for laying the tracks (Figure 3).

Figure 3. A drainage channel lined with geotextile and tank tracks.

b. Workers then were able to direct the tracks into place using as few as three people. Figure 4 shows how the tracks are laid in a stairstep fashion.

Figure 4. Tracks laid in a stairstep fashion.

c. The tracks are toed under the adjacent roadway so as to interlock at the road/drainage channel interface (Figure 5). Asphalt will be used to anchor the tracks into place under the water flow line. This will allow the water to run over the tracks and road surface and prevent gullying.

Figure 5. Tracks toed under the adjacent roadway.

d. Natural inlets were lined (Figure 6) to direct water into the main drainage channel. The channel sides are also armored. The tracks are toed into the soil profile and under the waterflow line.

Figure 6. Tank tracks lining a natural inlet.

e. Tracks laid at the road/drainage channel interface were toed into the soil profile under the water flowline and later partially covered with asphalt (Figure 7).

Figure 7. Tracks toed into the soil profile under the waterflow line.

f. Figure 8 shows a spot downstream from the project site. Notice the utility pole being slowly scoured away by erosive forces.

Figure 8. Erosion and scouring downstream from the project site.

g. Figure 9 shows the same general downstream area 2 years after the project was completed. Vegetation is establishing slowly, but most is washed away during rain events.

Figure 9. Vegetation is slow to establish downstream from the project site.

h. Figure 10 shows the upstream area 2 years after the tracks were laid for the project. Vegetation is establishing well and no further maintenance is needed. An erosion study was conducted to compare erosion rates between the tracked area and untracked area. Erosion was significantly higher in the untracked area, whereas the tracked area had significant levels of deposition occurring (Appendix B). At this point, the tracks can still be seen to some degree.

Figure 10. The project area 2 years after tank tracks were placed.

(3) Hardened Streamcrossings: Fort Carson had a heavily trafficked tank trail used by personnel in the Army, National Guard Bureau, Army Reserve units, dog trainers, physical trainers, etc. This tank trail could accommodate tank passage during dry times of the year. However, several vehicles and tanks have had to be towed out of the crossing when soil moisture levels were high. Since this particular area is mostly alluvial clays, the soil quickly becomes saturated and is similar to quicksand. A hardened streamcrossing was needed in this area to allow safe access year-round for troops.

a. Figure 11 shows the crossing as it was before implementing a hardened streamcrossing. A professional engineer from the Engineer Research and Development Center (ERDC) surveyed and flagged the site, developed the specifications, and wrote the Statement of Work to hire the contractor. BMPs were followed to ensure erosion was kept to a minimum while the work was being performed.

Figure 11. Heavily trafficked tank trail crossing before hardening.

b. Unserviceable tank tracks from the DRMO yard were hauled to the project site (Figure 12). Each individual pallet held four lengths of track. Each track was 4 feet long and approximately 400 pounds. To complete the streamcrossing, the staff used 68 pallets of track to form a 20-foot x 100-foot mat that spanned the stream.

Figure 12. Tank tracks awaiting placement.

c. The track was lined up in 20-foot sections and connected end to end using spare parts from other tracks (Figure 13). Multipurpose lubricant spray was used to help ease the connectors onto the end shanks of the tracks. Preparing and laying the tracks requires intensive labor. To assemble 44 strips of 20-ft track, it took three FTE 3 days to accomplish; 72 to 80 manhours are needed to assemble a project of this magnitude.

Figure 13. Preparing the track for placement.

d. While the workers were assembling the tracks upslope, excavation, grading, contouring, and filling were being carried out at the crossing (Figure 14). Stream water was diverted from the project area using two pumps.

Figure 14. Earthmoving at the crossing.

e. The crossing was filled with the following layers starting at the bottom of the stream channel (Figure 15):

1. Base = 6 inches compact fill
2. Nonwoven geotextile
3. 24 inches of riprap (d50: 6 to 12 inches)
4. 8 inches compacted gravel
5. 4-inch tank track mat (1 layer thickness of tracks)
6. 6 inches of gravel (ABC 3-1/4-inch stone with fines)

Figure 15. The bottom layers of the project.

f. Tracks were laid (Figure 16) using a cable, backhoe, toploader, and one worker to guide the placement.

Figure 16. Placing the tracks.

g. The backhoe operator was then able to move the track into the final position on the ground (Figure 17).

Figure 17. Moving the tank tracks into final position.

h. Rust-resistant stainless steel cable (1/2 to 5/8 inches) was used to string together the mat into a cohesive unit (Figure 18). Approximately 1,100 feet of cable was used to string the tracks. Of that total, over 750 feet of cable and 100 clamps were salvaged from the DRMO yard and other units on Fort Carson. Stream flows may be able to dislodge a single 400-pound section of track. Stringing the tracks together creates a unit weighing more than 88,000 pounds and provides a backup system if one string fails.

Figure 18. Using cables to string the tracks together.

i. Cables were secured on either side by clamps (Figure 19). Insertion points were staggered to offset potential loads.

Figure 19. Using clamps to secure the cables.

j. A layer of gravel was applied to finish the project (Figure 20). The final project costs were as follows:

1. Materials (including silt fence, fabric, riprap, fill, gravel, cable, and seed):	$11,200
2. Labor:	$25,972
Total:	$37,172

The final cost was $18.58/ square foot.
Keep in mind this is a contracted project. With troop labor, costs could be reduced.

Figure 20. A layer of gravel covers the final project.

e. Summary

Reducing the volume of solid waste generated by Army activities is imperative in creating a sustainable future. The Army has been very resourceful in implementing solid waste management programs that are very diverse, creative, and effective. Finding alternative uses for waste materials like tank tracks is one tactic to add to the suite of methods already employed. The potential uses for tank tracks are substantial and can provide a plethora of benefits including: reduced volumes of solid waste for disposal, hardened sites for training, and erosion control structures that are robust.

APPENDIX B

Erosion Data Analysis

Methods

All calculations were processed using an Intel Celeron 300A computer system from Ikon Technologies, Inc. Statistical analyses were performed using SAS® Release 8.00 TS Level 00M0.

The observational unit in the data was an erosion pin. The measurements were taken at days 0, 14, 28, and 42 following intermittent rainfall events. There were three repeated measures taken at each pin. No further transformations of the data were necessary. The data were analyzed using the mixed-models analysis of variance procedure implemented in SAS PROC MIXED. The Fort Carson data were analyzed using a 3-way factorial analysis of variance model with the factors TRACKS (Levels: "Yes", "No"), POSITION (Levels: "Top", "Middle", "Bottom"), and the repeated measure DAY (Levels: 84, 98, 126). The Colorado Springs data were treated as a 2-way factorial design with factors TRACKS and DAY, because all data at this site came from the "Top" level of POSTION. The days between successive measurements were not equal. Therefore, spatial covariance functions in PROC MIXED were used to produce a time-series covariance structure in which the correlations declined as a function of time was incorporated in the repeated measures analyses of variance, as described in Littell et al. 1996[1]. In both analyses, the "Linear Log" spatial covariance structure, applied to the time series, provided the best fit to the data, relative to the other spatial covariance structures listed in Littell et al. 1996, by Akaike's Information Criterion and Schwarz's Bayesian Criterion.

Results

The results for Fort Carson showed a "TRACKS*DAY" interaction significant at the .05 level ($.05 < p < .001$). Figure B1 illustrates the least-squares means for this interaction. Note the pattern over time is different for the cases with vs. without tracks (Y and N, respectively), with the difference measure increasing monotonically. TRACKS = "Yes" at DAY = 42 suggests that the only significant erosion was in the tracked treatments. The differences between tracked and non-tracked treatments were not significant at any single point of measurement.

The results for Colorado Springs also showed a "TRACKS*DAY" interaction significant at the .05 level ($.05 < p < .001$). Figure B2 illustrates this interaction. The values are negative at day 0, significantly so for the nontracked treatment, indicating some deposition, as opposed to erosion. In the tracked treatment, deposition increases over time, while in the nontracked treatment the deposition is reversed (eroded) over time. The differences between tracked and nontracked treatments were not significant at any single point of measurement.

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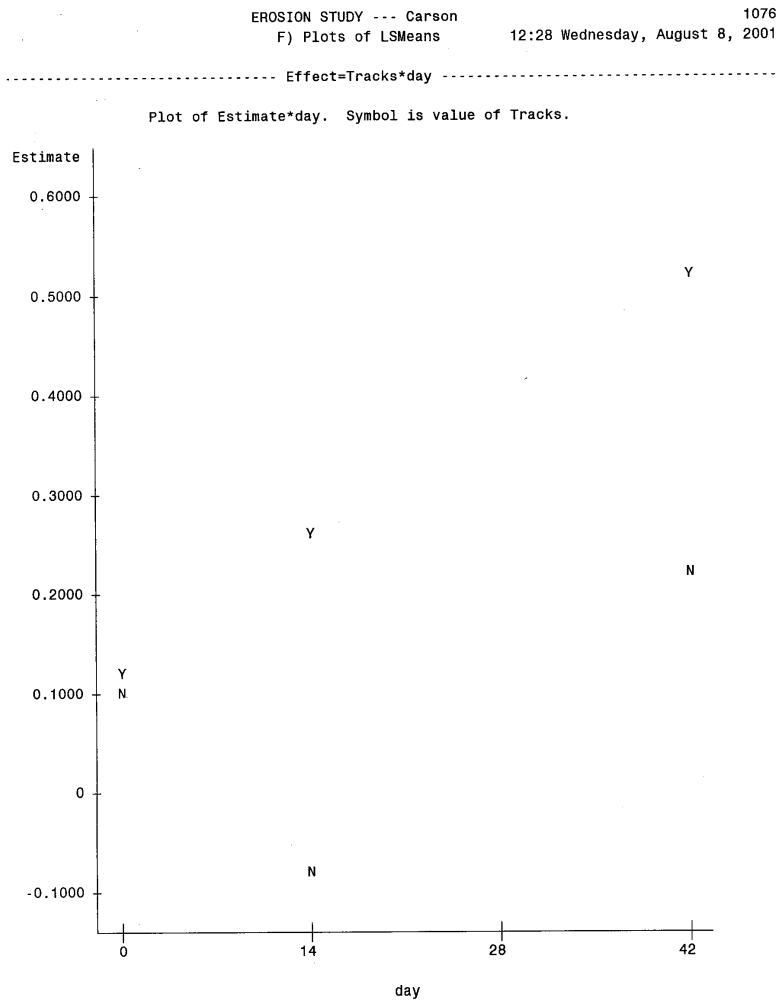
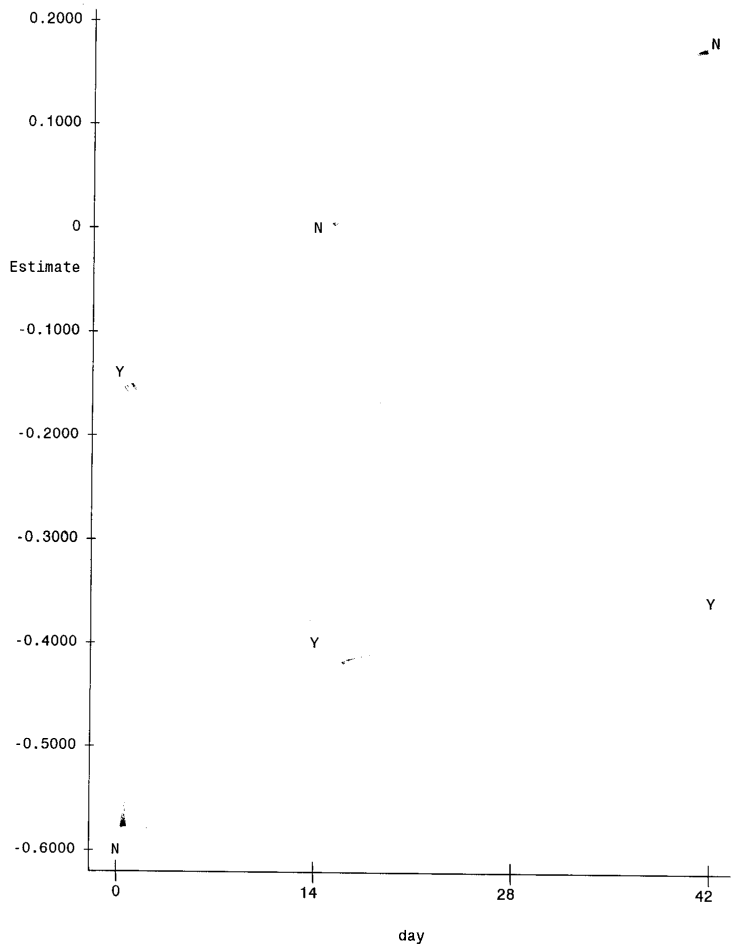
[1] Little, Ramon C, George A. Milliken, Walter W. Strout, and Russel D. Wolfinger (1996) Preface to *SAS System for Mixed Modules*. SAS Institute Inc.

Summary

Over time for both the Fort Carson and Colorado Springs sites, significance did occur. The tracks at Fort Carson that were applied against the contour and without geotextile resulted in a contribution to erosion. The tracks placed at Colorado Springs contributed to deposition, not erosion. This is a result of proper placement and the use of geotextile, which prevented undercutting.



---------- Effect=Tracks*day ----------

Plot of Estimate*day. Symbol is value of Tracks.